D 000 735 696 7
UC SOUTHERN REGIONAL LIBRARY FACILITY

ACM Curricula Recommendations for Related Computer Science Programs *in Vocational-Technical Schools, Community and Junior Colleges, and Health Computing*

Volume III

acm

Association for Computing Machinery

ACM Curricula Recommendations for Related Computer Science Programs *in Vocational-Technical Schools, Community and Junior Colleges, and Health Computing*

Volume III

acm

Association for Computing Machinery

Association for Computing Machinery
11 West 42nd Street
New York, NY 10036

Compiled by the ACM Education Board

Price: ACM Members: $20.00
Non-members $26.00

Copies may be ordered, prepaid, from:
ACM Order Department
P.O.Box 64145
Baltimore, MD 21264

ACM order #201833

Copyright ©1983 by the Association for Computing Machinery

ISBN: 0-89791-119-9

CONTENTS

Page

Recommendations and Guidelines for a Career Program in Data Entry Operations 1-58

Recommendations and Guidelines for a Career Program in Computer Operations . . . . 59 - 124

A Model Curriculum for Doctoral-Level Programs in Health Care Computing . . . . 125 - 206

Recommendations and Guidelines for an Associate Level Degree Program in Computer Programming . . . . 207 - 229

RECOMMENDATIONS AND GUIDELINES
FOR
A CAREER PROGRAM IN DATA ENTRY OPERATIONS

ABSTRACT

This report offers recommendations and guidelines for a career program to educate data entry operators for work in data processing jobs. It represents the result of several years of effort by the Association for Computing Machinery's Committee on Curriculum for Community and Junior College Education, and is the consensus of a large number of computer educators and industry representatives.

The guidelines presented here are applicable to programs in vocational-technical schools at all levels, community and junior colleges, and other post-secondary institutions. They may be of use in evaluating existing programs or in establishing new programs.

The report provides objectives for a data entry operations curriculum and gives a detailed topical outline for its implementation. The topics are presented in the form of modules that can be selected according to the needs of the community served by the institution. The report also provides recommendations concerning equipment, faculty, and other resources necessary to offer a program in data entry. Recognition is given to the increasing responsibilities of data entry personnel and the crucial role they play in the efficient and successful operation of computer-based systems.

KEY WORDS AND PHRASES:
certificate programs
community and junior colleges
computer
curriculum
data entry
data entry operations
data processing
education
keypunch
two year programs
vocational-technical schools

CR CATEGORIES:
1.51 High school courses and programs
1.52 University courses and programs
2.42 Personnel training
3.5 Management data processing

TABLE OF CONTENTS

Preface.. 7

1. Introduction.. 8
    1.1 Current Status of Data Entry Education........................ 8
    1.2 Purpose of the Report.. 8

2. Data Entry Jobs: Prospects, Skills, and Environment............... 10
    2.1 Duties of the Data Entry Operator............................ 10
    2.2 Job Descriptions.. 11
    2.3 Job Environment.. 12
    2.4 Career Paths and Advancement................................ 12
    2.5 Employment Requirements..................................... 15
    2.6 Qualities for Success....................................... 16

3. Objectives of the Data Entry Curriculum........................... 17

4. Content of the Data Entry Curriculum.............................. 18
    4.1 Data Entry Topics... 18
    4.2 Related Topics.. 32

5. Resources for Curriculum Implementation........................... 33
    5.1 Faculty... 33
    5.2 Equipment... 33
    5.3 Advisory Committees... 33
    5.4 Instructional Aids.. 34

References... 35

Appendices... 38

A. References Materials.. 39
    A.1 Textbooks.. 39
    A.2 Audio-Visual Materials................................. 40
    A.3 Manuals.. 41
    A.4 Exercises and Programmed Instruction Books............. 43
    A.5 Periodicals.. 44
    A.6 Other References....................................... 46

B. Environment Considerations.................................... 48
    B.1 Specific Brands of Data Entry Equipment................ 48
    B.2 Guidelines for Speed and Accuracy...................... 49

C. Vocabulary.. 51

D. Student Clubs and Data Entry Organizations.................... 54

E. Aptitude Tests.. 55

F. Contributors and Workshop Participants........................ 56

G. ACM Committee on Curriculum for Community and Junior College Education, 1981.................................... 58

PREFACE

This report was prepared by the ACM Committee on Curriculum for Community and Junior College Education, under the auspices of the Education Board of the ACM. Work has been coordinated by Iva Helen Lee, McLennan Community College in Waco, Texas, with assistance from Donna Hutcheson, ARCO Oil and Gas Company, Dallas, Texas. The activities of the group were under the guidance of the Chair of the Committee, Joyce Currie Little, Community College of Baltimore, Maryland.

Efforts toward this report were initiated at a planning session held in February, 1977. Work on a draft report spanned several workshop sessions, with several rounds of review being done. The working paper was published in the ACM SIGCSE Bulletin, September, 1979. Presentations based on the report were given at several ACM symposia and conferences between 1978 and 1980. Comments and reactions were evaluated and discussed by the group, resulting in this final document.

Members of the Committee and the working group on data entry operations would like to thank all those who contributed toward the preparation of this report. The committee would especially like to thank Dr. Gerald L. Engel, Christopher Newport College, Newport News, Virginia who was Chairman of the ACM Curriculum Committee on Computer Education during most of the time of this work, and the Virginia Institute of Marine Science, Gloucester Point, Virginia, for hosting our first working session. We also extend thanks and our gratitude to Dr. Richard H. Austing and Dr. William F. Atchison, University of Maryland, College Park, who were ACM Education Board Vice-Chairman and Chairman, respectively, during most of this work.

Support from the computer community, the educational community, and from ACM has been gratifying. Numerous persons have sent contributions to the topical outline, directed us to references, recruited reviewers, served as reviewers, assisted us with copying and typing services, and given us encouragement to continue. Names of the Committee, workshop participants, and others who contributed toward the production of this report are given in Appendix F and G. Special thanks are sent to the National Technical Institute for the Deaf at Rochester Institute of Technology for assistance with manuscript production, and to our editor, Maureen Shumate, for her work.

We hope this work will be of benefit to the industry. ACM and the Committee would be pleased to hear how it has been of use to you.

1. Introduction

The importance of the data entry function is well recognized and documented. (11) Since responsible and accurate entry of data is crucial to the production of timely and correct reports, the data entry operator plays an important role in the efficient and successful operation of computer-based systems. (2)

This report addresses the education of data entry operators. It has been prepared for the use of educational institutions such as junior and community colleges, vocational-technical schools, and technical institutes. As such, it stresses the importance of currency in data entry programs. Data entry programs must continue to keep pace with current technology and be responsive to the needs of the community.

1.1 Current Status of Data Entry Education

There are few formalized programs for the training of data entry operaters. Instead, it has been common practice for supervisors or equipment manufacturing personnel to train clerks or typists to assume data entry duties. Educational institutions that do offer data entry training include secondary schools, vocational institutes and proprietary schools, junior/community, colleges and senior colleges.

In public schools and colleges, data entry courses may be offered in data processing/computer science departments or business departments. Of the courses examined at the time this report was written, most were titled "keypunching" rather than "data entry." (28) And of those titled "data entry," many were primarily keypunch oriented.

It is important that data entry personnel have some formal training. With data entry and other computer equipment becoming increasingly sophisticated, speed, accuracy, and a basic understanding of data processing are necessities for anyone seriously considering data entry as a career.

In many ways education lags behind industry, and technical courses become obsolete rapidly. An up-to-date, model curriculum for the teaching of data entry is therefore needed most urgently.

1.2 Purpose of the Report

In the hope of serving the profession well, the subcommittee has prepared this report with the following the objectives in mind:

1. To assist institutions in establishing new programs in data entry.

2. To assist institutions in updating existing programs in data entry.

3. To contribute to the establishment of nationally recognized standards for programs in data entry operations.

4. To upgrade the image of data entry operators as playing an important role in computer-based information systems, and correspondingly to improve their performance and increase their self-esteem.
5. To promote data entry as a profession in itself and encourage its recognition as such among other data processing professionals.

2. Data Entry Jobs: Prospects, Skills, and Environment

The term "data entry device" refers to equipment that "captures data at its source or converts source data in human-readable form into any of a variety of codes that can be interpreted by a computer. These devices can either enter the data directly into a computer or record the data on an intermediate medium for subsequent entry." (7)

Typical data entry devices include:

- unbuffered keypunch
- buffered keypunch (data recorder)
- key-to-tape
- key-to-cassette
- key-to-disk
- key-to-diskette
- optical readers (character or mark)
- point-of-sale machines
- timesharing terminals
- light pens or wands
- voice input
- handwriting (4)

2.1 Duties of the Data Entry Operator

An entry level position for a data entry operator may carry a variety of titles depending on the type of shop, type of industry, or geographic area. In general, however, all persons applying for such positions must be prepared to:

1. Operate data entry equipment to convert source data into coded form on machine-readable media such as punched cards, paper tapes, magnetic tapes, cassettes, magnetic disks, or diskettes.

2. Verify, in accordance with instructions, the accuracy of data recorded visually and/or mechanically.

3. Correct minor problems on external components of the equipment.

4. Perform minor preventive maintenance on the equipment.

5. Identify incomplete or obviously inaccurate source documents, and take appropriate action in accordance with the installation's policies and procedures.

6. Monitor and/or operate related peripheral equipment (e.g., a diskette-to-tape converter) to produce desired records.

7. Prepare prescribed record formats and implement their use.

8. Review and organize source documents in preparation for processing.

9. Record selected data from business forms and documents according to operating instructions.

10. Record and maintain proper documentation for all production work as prescribed by the installation's policies.

11. Perform general clerical assignments as required.

12. Follow the installation's security procedures and policies, recognizing and reporting security violations or weaknesses.

2.2 Job Descriptions

Job descriptions of data entry positions are published periodically in Datamation, Infosystems, and the Occupational Outlook Handbook. The descriptions in these periodicals closely parallel the following, which were taken from "Hansen's Weber Salary Survey on Data Processing Positions." (14)

1. Data entry supervisor. Under supervision of the operations manager of data operations, plans, schedules, supervises, and directs data entry and verification activities; maintains the corresponding files; supervises assigned personnel to carry out the above activities.

2. Lead data entry operator. Under direct supervision, assists in supervising a group engaged in operating data entry devices in recording a variety of data; assists in the scheduling of data entry functions; instructs operators on procedures used to perform routine assignments; trains new employees.

3. Data entry operator A. Under direct supervision, operates data entry devices in recording a variety of data; may instruct operators on procedures used to perform routine assignments; may assist in training new employees.

4. Data entry operator B. Under direct supervision, operates data entry devices in recording a variety of data; verifies data entered; performs related clerical duties.

5. Data entry operator C. Under direct supervision, usually performs data entry on a volume basis with only one or two input formats and one type of data entry device. May assist occasionally on other types of work.

6. Data entry operator - trainee. Under direct supervision, undergoes training as a probationary employee to determine suitability for data entry work.

2.3 Job Environment

Statistics on data entry salaries are published annually in Datamation and Infosystems. Current salaries are easily located since they are usually published in the same month every year.

The environment in which a data entry operator works varies with the type of industry, geographic area, size of the facility, and other factors. Generally, though, the operator will work in a facility having either of two basic configurations of equipment: centralized or decentralized (distributed). These terms refer to the location of data entry devices with respect to other data entry devices and/or the central processor. In a centralized configuration, all data entry devices are in one location, usually in close proximity to the central processor. A distributed configuration has one or more data entry devices located at a site remote from the central processor, or several devices located at different sites, each site having editing capabilities but minimal processing power.

In a centralized environment, data entry personnel typically report to the manager of computer operations or data processing operations and usually work in a group with other operators under a data entry supervisor or manager. In a decentralized environment, the data entry operator may work alone or with a group of other operators, but is usually under the supervision of the user department.

The environment in which a data entry operator works may also include word processing equipment. The relationship between data entry operations and word processing operations has been much discussed in the literature. (21) Although now word processing is typically found in an office setting and is typically done by office personnel, much of this type of work may eventually be assumed by computer services groups and delegated to data entry operators. (9) Curriculum coordinators, along with business office secretarial departments, and industry at large, should follow closely the developments and trends in computer-aided documentation and adjust their perspectives and needs accordingly.

2.4 Career Paths and Advancement

With the infiltration of computers into all parts of the business community, the demand for trained data entry operators is increasing. According to the Bureau of Labor Statistics, the expanding use of computers will cause the demand for data entry operators to grow faster than the average for all occupations during the period 1972-1985 (the average for all occupations projected for that period is 20.3%). (24) The Data Entry Management Association's 1979 member equipment survey supports the prediction, and notes a sharp rise in the number of member companies expecting data entry staff increases. (8)

As the need for data entry operators grows, so does the potential for career growth. With recent advances in computer technology, data entry has become more professional. It is now possible for a data entry operator to advance in several ways. Figure 1 shows how this might happen in a large shop. Note that once beyond the training stage, a data entry operator can choose the computer operations, data control, or data entry route. All lead upward and still allow the operator to remain close to data entry.

Career possibilities in a small shop (see Figure 2) differ from those in a large shop. Because of the limited number of people in a small shop, the data entry operator may perform tasks similar to those done by several people in a large shop. Eventually the small-shop operator may become proficient in one task or another and decide to specialize. Although this generally means seeking work at a larger company, he or she may decide to remain with the company and grow as the company grows.

Figure 1. Career possibilities in a large shop.

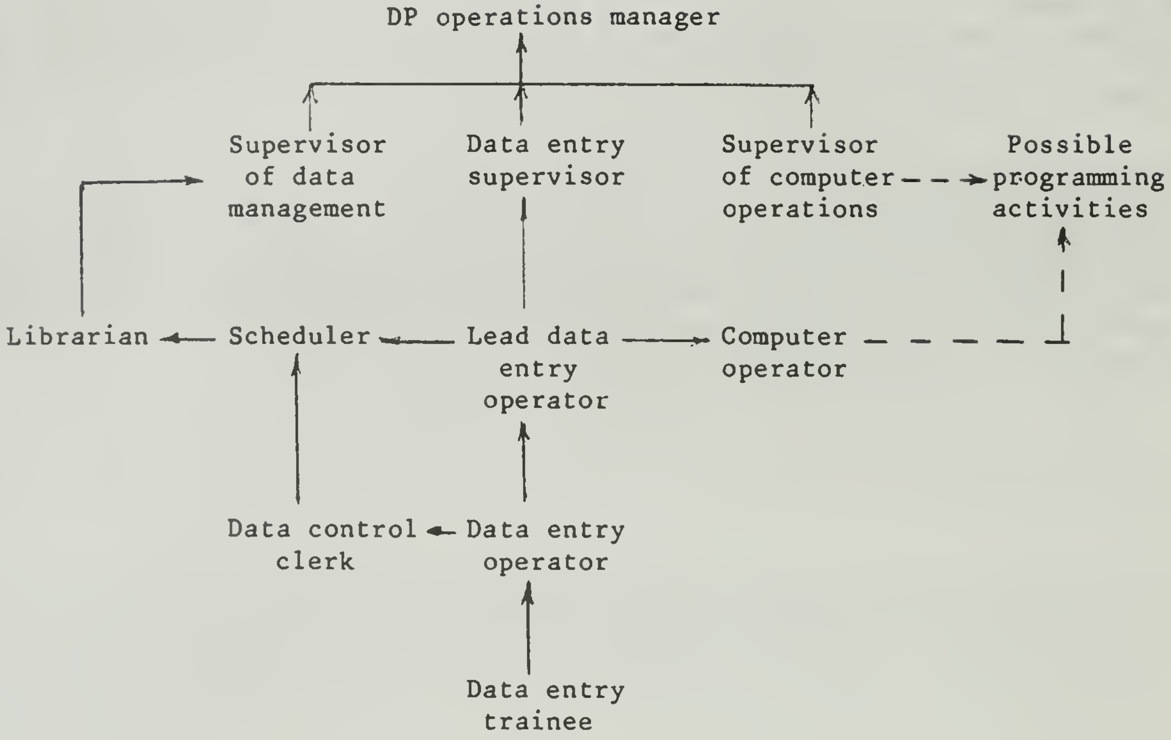
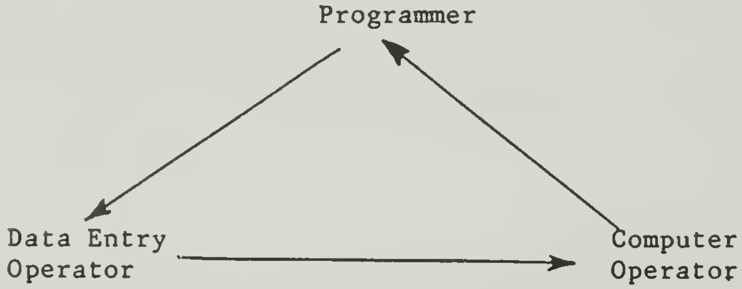


Figure 2. Small shop career possibility.



2.5 Employment Requirements

Inspection of classified advertisements shows a wide range of requirements for employment as a data entry operator. Desired experience ranges from three months to four years. Trainees are rarely mentioned. Occasionally, however, companies looking for persons with a few months of experience may hire trainees showing exceptional potential.

Prior to employment, job applicants may be asked to take certain tests. Companies generally require applicants for data entry positions to be tested for speed and accuracy; some provide further testing to detect error patterns. Aptitude tests are not commonly administered. However, at least one company (see Appendix E) has devised its own, and some use IBM Keypunch Aptitude tests, even though IBM no longer publishes the test.

Once employed, the data entry operator is judged by total performance on the job - by his or her production capabilities, accuracy, flexibility, attitude, attendance, and punctuality. (27) Although industry emphasizes speed and accuracy, differing hardware environments and data entry needs prevent the establishment of a single industrial standard. Appendix B.2 presents general guidelines for establishing speed and accuracy requirements for data entry training. We must emphasize, however, that these are only guidelines; each institution should determine local community standards for testing speed, and accuracy before accepting these or any guidelines.

Data entry trainees should be prepared to work on night shifts and to work under the pressure and deadlines inherent in a production environment. They must operate machines continuously, sitting for long periods of time. And they are often subjected to eye strain and continuous machine noise, although recent equipment advances are rapidly improving these conditions. (16)

2.6 Qualities for Success

Successful industrial data entry operators generally possess the following qualities:

1. Ability to follow both oral and written instructions.
2. Ability to give attention to detail.
3. Good concentration skills.
4. Ability to work under pressure and meet deadlines.

Handicapped students, such as the deaf and wheelchair-bound, have demonstrated success in the data entry field. Students who have proven typing skills of 30-35 wpm should progress much more rapidly in this program.

3. Objectives of the Data Entry Operations Curriculum

The primary purpose of this curriculum is to produce data entry operators well prepared to fill entry level positions in local industries. A secondary purpose of the curriculum is to provide data entry operators with sufficient background to enable them, with further on-the-job training, to progress to other positions, such as those mentioned in the previous section.

The many types of data entry equipment available as well as differing community environments made the selection of objectives for the curriculum, as indeed the curriculum itself, particulary difficult. After much deliberation, it was decided to build the curriculum into a set of modules or units based on the most commonly used types of equipment, so that institutions need teach only those units relevant to their respective communities. It was then an easy matter to formulate objectives for the curriculum. Each unit carries its own set of objectives. Taken together, they comprise the overall objectives of the data entry curriculum.

4. Content of the Data Entry Curriculum

Each institution planning to offer a data entry program should analyze the needs of its community, and then design the curriculum to meet those needs. A program that serves small shops may be quite different from one serving large corporations. The length of a program may vary from several months to two years, and may warrant the granting of a diploma, a certificate, or a degree. Data entry programs based on the curriculum guidelines presented here are adaptable to secondary vocational schools, post-secondary vocational-technical institutes, community and junior colleges, colleges, universities, and proprietary schools.

4.1 Data Entry Topics

The subject matter recommended for a data entry program is in topical outline form, separated into distinct units or modules (see Table I). We strongly suggest that Unit I (Introduction to Data Entry), Unit XII (Employment Preparation), Unit XIII (Data Control), and Unit XIV (Laboratory Work) be placed in all curricula, with other device-dependent units added according to the needs of the local job market. Units chosen should be organized into courses, then combined with related courses to produce a curriculum. For example, a school serving mostly small card-oriented business applications shops would perhaps include Unit III (Unbuffered Keypunches), Unit IV (Unbuffered Verifiers), Unit V (Buffered Keypunches (Data Recorders)), and Unit VII (Key-to-Diskette Devices), while a school serving most online, real-time large shops would probably include Unit VIII (Key-to-Disk Devices), and Unit IX (Timesharing Terminals).

Designing a specific curriculum based on these topics is not a trivial task. Once units are chosen, course structures must be established, and laboratory assignments and exercises developed. The data entry laboratory must be designed, and equipment obtained and installed. Once functioning, the laboratory must be maintained. It should reflect the same degree of attention and care that a data entry laboratory would warrant in industry. Institutions should not take on these tasks irresponsibly, since they require a continuing commitment of time, staff, and money.

Table I. Modular course outline.

Unit I: Introduction to Data Entry Operations

A. Definition of data entry
B. General types of data entry equipment
C. Development of current data entry concepts and how they relate to the computer
D. Data entry system configurations (18, 22, 33)
    1. Centralized data entry
    2. Distributed data entry
E. Duties and job descriptions of data entry personnel

OBJECTIVES. Upon completion of this unit, each student should be able to:

- Define and properly use terms associated with data entry operations.
- Identify the principal devices currently utilized for data entry.
- Compare and contrast the major characteristics of centralized data entry shops and distributed data entry shops.
- Given a general data entry configuration, identify it as centralized or distributed.
- Discuss the impact of computer technology advancement on the data entry job market.
- Define punched card data processing and the unit record principle.
- Summarize historical developments leading to current data entry concepts.

Unit II: Record Design

A. Coding schemes and related terminology
    1. Hollerith
    2. Binary coded decimal (BCD)
    3. Others as applicable to local use
B. Data fields and design considerations (11)
C. Job instruction and transmittal sheets

OBJECTIVES. Upon completion of this unit, each student should be able to:

- Demonstrate a working knowledge of the Hollerith and BCD coding schemes by writing the codes for letters and numbers.
- Given an uninterpreted 80-column punched card, use the Hollerith code to determine what data is punched in specified columns of the card.
- Given an uninterpreted 96-column punched card, use the BCD code to determine what data is punched in specified columns of the card.
- Given a source document, design an appropriate record format.
- Discuss data attributes to be considered when designing input record formats.
- Describe the functions of job instruction sheets.

Table I. Modular course outline (contd).

- Explain the impact of job instruction sheets on accurate data entry.
- Demonstrate correct use and handling of job instruction sheets and transmittal sheets in a productive data entry environment.

Unit III: Unbuffered Keypunches

A. Care and handling of cards
B. Component parts, the keyboard, and functional control keys
C. Basic operation (no program control)
    1. Numeric punching
    2. Alphabetic punching
    3. Duplication
    4. Error correction
D. Machine malfunction and care
    1. Removing card jams
    2. Unlocking the keyboard
    3. Ribbon replacement
E. Program drum and basic program control
    1. Parts of the program unit and how it operates
    2. Program card codes
    3. Analysis of source document and program card coding
    4. Program control punching
    5. Left zero insertion
    6. Alternate program control

OBJECTIVES. Upon completion of this unit, each student should be able to:

- Demonstrate the correct way to fan, flex, and joggle cards when working in a card data entry environment.
- List at least three causes of card jams on card-oriented equipment.
- Demonstrate the correct procedure for removing a card jam.
- Identify and give the function of all external components of an unbuffered keypunch machine.
- Demonstrate basic operation of the unbuffered keypunch machine when punching numeric, alphabetic, and alphameric fields of data.
- Demonstrate the procedure for duplicating a damaged card.
- Demonstrate the correct procedure for adding data to given columns of a punched card.
- Demonstrate the correct procedure for correcting a mispunched card.
- List the causes for a locked keyboard and give corrective procedures.
- Demonstrate the procedure for changing a ribbon.
- Contrast machine operation with and without left zero programming.
- Demonstrate the correct procedure for mounting a program card on the drum.
- Plan and prepare a program card for program levels 1 and/or 2.
- Demonstrate effective use of program control for a typical production application.

Table I. Modular course outline (contd).

Unit IV: Unbuffered Verifiers

A. Purpose of verifying
B. Operating features and principles
C. Operating with program control
D. Verifying exercises

OBJECTIVES. Upon completion of this unit, each student should be able to:

- Explain the purpose of verifying.
- Given a verified card, identify the card as correctly punched or incorrectly punched; and if incorrectly punched, locate the errors.
- Identify and give the functions of all external components of an unbuffered verifier.
- Verify punched cards.

Unit V: Buffered Keypunches (Data Recorder)

A. Advantages over unbuffered equipment
B. Types of equipment available
C. Internal operations (buffer concept)
D. External components (operating features, controls, and indicators)
E. Modes of operation
    1. Manual punching
    2. Automatic or program punching
        a. Program codes
        b. Program preparation
        c. Program load
        d. Program punch out
        e. Program selection
    3. Corrections and duplications including loading data
    4. Special operation problems
        a. Recovery procedures and keyboard lockups
        b. Card and machine care
        c. Programming and field format hints
    5. Format chaining
    6. Optional features
        a. Production statistics
        b. Accumulation of batch or hash totals
        c. Self-checking number device (modulus 10 or 11)
        d. Direct punch control
        e. Verify read control
        f. Interpreting
    7. Verifying
    8. Exercises

Table I. Modular course outline (contd).

OBJECTIVES. Upon completion of this unit, each student should be able to:

- Explain the major differences between unbuffered and buffered keypunches.
- Describe the flow of data into, through, and out of the machine.
- Identify the functions of all external components of a buffered keypunch.
- Plan and prepare program cards to be used on a buffered keypunch.
- Demonstrate correct procedures for loading program cards, punching program cards from machine buffers, and using one or more program levels in a program-controlled production problem.
- Demonstrate the correct procedures of duplicating data from previous cards with or without program control.
- Demonstrate the correct procedures for adding data to punched cards and correcting mispunched cards.
- List the causes for a locked keyboard and identify corrective procedures.
- Describe and/or demonstrate effective use of optional features, such as production statistics, accumulation of totals, self-checking number devices, direct punch controls, and interpreting.
- Name and demonstrate correction procedures for errors detected when verifying.
- Given verified cards, identify the ones punched correctly and the ones corrected during the verification process.
- Verify punched cards.

Unit VI: Key-to-Tape Devices

A. Magnetic tape
    1. Characteristics
    2. Tape vocabulary--density, tape mark, end of file, labels
    3. BCD and EBCDIC code representation
    4. Care, labeling, and handling of tape
    5. Types of tape (cassette, reel, cartridge) (3)
        a. Comparisons
        b. Pooling devices
B. Description of approaches (15)
    1. Key-to-tape, stand-alone
    2. Key-to-tape, pooling cluster
    3. Key-to-tape, verify central
    4. Key-to-tape, direct cluster
    5. Key-to-tape-to-editor cluster
C. Examples of specific brands (see Appendix B.1)
D. Operating features
E. Controls and indicators
F. Memory display, if applicable
G. Mounting of tapes or cassettes

Table I. Modular course outline (contd).

H. Basic operation modes
    1. Entry
    2. Verify
    3. Search
    4. Program
        a. Program codes
        b. Program load
        c. Program selection
    5. Error condition recoveries

I. Applications (19)

OBJECTIVES. Upon completion of this unit, each student should be able to:

- Describe unique characteristics of magnetic tape as a recording medium and contrast its characteristics with those of punched cards.
- Define and properly use terms commonly associated with magnetic tape as a data storage medium.
- Compare BCD and EBCDIC code representation of data.
- Given a desired field of data, write the corresponding BCD and EBCDIC codes.
- Demonstrate proper care and handling of tapes during all performance activities.
- Compare the major characteristics of three types of magnetic tape.
- Discuss at least three different approaches to key-to-tape data entry.
- Identify and explain the function of all external components of a key-to-tape machine.
- Name three basic operating modes available on key-to-tape equipment.
- Demonstrate correct operation of equipment in each operating mode.
- Describe and/or demonstrate the correct procedure for error condition recoveries.
- Given the appropriate job format, prepare the program(s) necessary to record and/or verify the job records.
- Load programs into program memory.
- Under program control, record and subsequently verify a set of given records. During these operations, correct data when necessary.
- Under program control, demonstrate the correct procedure for a search operation.

Unit VII: Key-to-Diskette Devices

A. Diskette
    1. Terminology (tracks, sectors, etc.)
    2. Care, labeling, and handling of diskettes

B. Advantages over key-to-tape devices

C. Types of devices
    1. Single-station (floppy disk)
    2. Multi-station system (29)

Table I. Modular course outline (contd).

---

a. Offline key-to-disk-to-tape
b. Online key-to-disk-to-computer
c. Offline key-to-drum-to-tape
3. Associated peripherals
D. Specific brands (see Appendix B.1)
E. Operating features (keyboard, display screen)
F. Controls, indicators, and special keys
G. Diskette addressing
H. Basic operation
1. Index, entry, and update modes
2. Using programs for entry/update modes
3. Status line components and error codes
4. Adding/deleting/changing records
5. Verifying
6. Identifying data on diskette
7. Searches
8. Disk copy
9. Creating and changing labels
10. Storing programs
11. Format chaining
12. Field totals
13. Self-checking numbers
I. Special features
J. Exercises

OBJECTIVES. Upon completion of this unit, each student should be able to:

- Define and properly use terms associated with key-to-diskette data entry equipment and diskette recording media.
- Identify the advantages of key-to-diskette devices over key-to-tape devices.
- Describe the physical features of a diskette.
- Discuss techniques for proper handling of diskettes.
- Identify and explain the function of all external components of a key-to-diskette machine.
- Demonstrate the proper procedure for loading and removing a diskette.
- List the types of information stored on the index track that concern the system and job titles.
- Describe the flow of data into, through, and out of a key-to-diskette machine.
- Name the operating modes available on key-to-diskette equipment.
- Discuss at least three operating environments for key-to-diskette data entry shops.
- Given the appropriate record format, create, load, and/or store the program(s) necessary to enter and/or verify a set of records.
- Under program control, record and subsequently verify a set of given records. During these operations, correct data when necessary.

Table I. Modular course outline (contd).

- Demonstrate the correct procedure for completing each of the available search operations.
- Given the appropriate address, copy data from one disk to another.
- Given an error code or verbal description of an error, list the possible causes and/or demonstrate corrective procedures.

Unit VIII: Key-to-Disk Devices

A. Minicomputers
    1. Editing data
    2. Data transmission
    3. Disk storage terms
B. Advantages over other magnetic media
C. Disk storage terms
D. Specific brands (see Appendix B.1)
E. Schematic diagrams of these systems (29) and merits of these systems
F. Operating features (keyboard and display screen, cursor)
G. Operating procedures
    1. Starting
    2. Start of batch entry
    3. Start of batch verify
    4. End of batch
    5. Restart batch, return to last mode
    6. Supervisor
H. Job control, if applicable
I. Special features
J. Exercises

OBJECTIVES. Upon completion of this unit, each student should be able to:

- Explain the arrangement of key-to-disk data entry devices with respect to a total communications system or a host computer system.
- Identify advantages of key-to-disk systems over other magnetic media systems.
- Identify the function of a minicomputer in a key-to-disk data entry system.
- Describe the physical features of a disk and a disk pack.
- Describe the flow of data into, through, and out of a key-to-disk device.
- Identify and explain the function of all external components of a key-to-disk device.
- Name the types of keyboards available on key-to-disk equipment.
- Compare and contrast data entry using formatted display vs. nonformatted display and formatted records vs. free-form records.
- List the various functions a program can assign to a field that affect the operation of that field.
- Demonstrate the procedure for retrieving a record format from disk.

Table I. Modular course outline (contd).

- Describe and/or demonstrate the concept of format chaining.
- Describe the log-in and log-off procedures for operating the key-to-disk devices at the laboratory site.
- Given an error, list the system reaction and corrective procedures.
- Identify the standard procedures and characteristics associated with the various operating modes of a key-to-disk device.
- List the effects of and subsequent procedures for system or station mechanical failure.
- Match available system commands with their outcomes.
- Given a system message, describe the probable cause of the message and possible operator action.
- Under program control, record and subsequently verify a set of given records. During these operations, correct data when necessary.

Unit IX: Timesharing Terminals (5, 6, 35)

A. Advantages over other key-to-disk equipment
B. Types of terminals: remote-batch, programmable, dumb, smart, intelligent, hyperintelligent (17), hard-copy, soft-copy
C. Uses: data entry, data retrieval, data inquiry/response (32)
D. Types of keyboards: typewriter, data entry, adding machine
E. Vendors (34)
F. Specific brands (34, 7) (also see Appendix B.1)
G. Typical system
    1. Schematic diagram showing relation to host system
    2. Supervisor-created programs or formats
    3. Basic features
        a. Display screen, cursor, wrapping, command line
        b. Keyboard
        c. Formats (programs) and format chaining
    4. Operating procedures
        a. Issuing commands
        b. Entering data
        c. Verifying
        d. Scanning
        e. Searching
        f. Restarts
        g. Duplication
        h. Record insert/delete and update
H. Applications (12)
I. Techniques for reliable keyed input (10)
    1. Default messages
    2. Positional messages
    3. Identified messages
    4. Checkwords
    5. Adaptive checking
    6. Tolerating variance

Table I. Modular course outline (contd).

J. Exercises

OBJECTIVES. Upon completion of this unit, each student should be able to:

- List identifying characteristics of the following types of terminals: timesharing, remote, remote-batch, programmable, dumb, smart, intelligent, hyperintelligent, hard-copy, soft-copy.
- Explain three major uses (or modes of use) of timesharing terminals.
- Name the keyboards available on timesharing terminals and describe the unique characteristics of each.
- Identify and explain the function of all external components of a timesharing terminal.
- Define the terms "protected" data and "unprotected" as they relate to formatted screens.
- Contrast formatted screens vs. non-formatted screens.
- Identify and explain the functions of the screen indicators.
- Given a job to enter, and appropriate key names, describe and/or demonstrate the correct procedure for "logging-in" and "calling up" the computer program to accept that job.
- Given an error, identify corrective procedures.
- Describe and/or demonstrate the concept of format chaining.
- List the effects of and subsequent procedures for system or station mechanical failure.
- Under program control, record and subsequently verify a set of given records. During these operations, correct data when necessary.
- Under program control, perform a search operation for records that are to be modified or deleted.
- State the major characteristics, advantages, and disadvantages (if any) of utilizing the following techniques for achieving reliable keyed input: default messages, positional messages, identified messages, checkwords, adaptive checking, tolerating variance.

Unit X: Constraints and Limitations of Other Data Entry Devices

A. Optical character recognition (OCR) devices (30, 25, 13)
B. Point-of-sale (POS) systems (23)
C. Magnetic ink character recognition (MICR) devices
D. Portable data recorders
E. Industrial data collection
F. Voice data entry
G. Pushbutton telephone
H. Direct hand entry

OBJECTIVES. Upon completion of this unit, each student should be able to:

- List at least six devices currently used for data entry that were discussed in previous units.

Table I. Modular course outline (contd).

- Identify and/or describe the major characteristics of and applications for the following:
  - OCR equipment
  - MICR devices
  - POS systems
  - Portable data recorders
  - Voice data entry
  - Direct hand entry
  - Any other devices currently in use for data entry that have not been previously covered in detail.
- Given a business environment and data processing situation, identify which of the following devices could be used for data entry:
  - Keypunches (buffered or unbuffered)
  - Key-to-tape
  - Key-to-disk (or diskette)
  - Timesharing terminals
  - OCR
  - POS
  - MICR
  - Pushbutton telephone
  - Industrial data recorder
  - Portable data recorder
  - Voice data entry
  - Direct hand entry
- Identify the data entry devices normally operated by site personnel rather than experienced data entry operators.
- Explain the current trends in end-user oriented data entry equipment.

Unit XI: Other Related Topics

A. Documents and document handling
B. Word processing (36, 31)
   1. Definition
   2. Relation to traditional methods of data entry
   3. Relation to text editing
   4. Future directions
C. Items to be considered in the evaluation and selection of data entry devices (20)

OBJECTIVES. Upon completion of this unit, each student should be able to:

- Identify the function and discuss the importance of job documentation as it relates to data entry, data verification, and peripheral equipment operations.
- Given a problem situation, identify and complete the documentation required. Such documentation must be written in a manner that is easily understood by all users of the documentation.

Table I. Modular course outline (contd).

- Describe the following characteristics of media-punched cards, magnetic tape, magnetic disk (or diskette):
    - Length of record
    - Ease of recording
    - Ease of verification
    - Ease of data search and retrieval
- Define the term "word processing."
- Describe situations in which data entry operators would be responsible for a word processing job.
- Discuss similarities and differences between word processing and traditional data entry operations
- Identify the validity of points to be considered when selecting new data entry equipment.
- Contrast the criteria used by data entry operators to evaluate a given machine with criteria used by management.

Unit XII: Employment Preparation

A. Applications and resumes for employment
B. Tests
C. Interview procedures
D. Data entry operator responsibilities and ethics
  1. Confidentiality of data
  2. Work habits
  3. Communications

OBJECTIVES: Upon completion of this unit, each student should be able to:

- Given a job application form, satisfactorily complete the form and write an associated cover letter.
- State the main areas of information covered in a resume.
- Write a satisfactory personal resume.
- Participate in several timed data entry speech/accuracy tests and complete typical job assignments.
- Participate in a mock job interview.
- Describe the major characteristics of specific types of job interviews (i.e., structured, unstructured, stress).
- State the rationale behind data confidentiality as a responsibility of the data entry operator.
- Identify the work habits that ensure data confidentiality.
- Write a brief memo describing a problem situation and requesting certain materials and/or equipment.
- Make an oral presentation describing a problem situation and/or requesting certain equipment.

Table I. Modular course outline (contd).

Unit XIII: Data Control (2)

A. Definition and objectives of data control
B. Types of controls that are the responsibility of the data entry operator
    1. Incomplete or missing documents
    2. Invalid codes
    3. Batch totals
    4. Logging
    5. Security
C. Other types of control
    1. Programmed controls
    2. Shared control systems

OBJECTIVES. Upon completion of this unit, each student should be able to:

- Define the term "data control" and list three objectives of data control (2).
- List the four types of data control (2) and give at least three examples of each.
- State the responsibilities and associated activities of a data entry operator in maintaining input data controls.
- Describe the functions of transmittal forms.
- Explain the impact of transmittal forms on accurate data entry.
- Given a procedures manual,
    - Log the receipt of input documents.
    - Verify the completeness of these documents and the correctness of balance totals, if any.
    - Label input documents for processing.
    - Verify the acceptability of output documents and balance totals, if any.

Unit XIV: Laboratory Work

NOTE: These laboratory exercises are to include verbal and written instructions (job instruction sheets).

A. Maintaining the work station
B. Recording numeric data
C. Recording alphameric data
D. Recording data under program control
E. Production exercises
    1. Payroll and time records
    2. Accounts receivable/accounts payable
    3. Billing and invoicing
    4. Inventories
    5. Lists of customers and addresses
    6. Word processing

Table I. Modular course outline (contd).

F. Computer programs as assigned (FORTRAN, COBOL, RPG, PL/1, ALC, etc.)
G. Utilizing precontrolled format
H. Utilizing free format
I. Time tests and error rate performance measurement
J. Maintaining and operating peripheral equipment associated with data entry equipment

OBJECTIVES. Upon completion of this unit, each student should be able to:

- Identify good housekeeping habits and incorporate them into his or her work.
- Demonstrate proper maintenance procedures as prescribed by the manufacturer of the equipment used.
- Without program control, satisfactorily key free-form numeric, alphabetic, and alphanumeric data sets.
- Given the appropriate record format and source documents for the jobs listed in the outline above,
  - Prepare and enter the required program codes.
  - Satisfactorily key all records.
  - Verify all records.
  - Complete all associated documentation.
- While completing all or any part of the above, identify and correct operator errors or machine malfunctions incurred.
- Operate and maintain peripheral equipment available for cleaning or conditioning recording media, identifying recording media, or converting recorded media to other machine-readable media.

4.2 Related Topics

The following related courses will contribute to the success of a data entry student in the job environment. The number of courses selected will depend on the goals and length of the curriculum.

1. Typing (with required minimum speed 35 wpm)--recommended as a prerequisite to the data entry program.
2. Business mathematics
3. Office machines
4. Clerical procedures
5. Introduction to business
6. Principles of business or personnel management
7. Business communications
8. Bookkeeping

The following data processing courses are suggested as electives. They should help data entry operators become more well-rounded, increasing their opportunities for employment and promotion:

1. Introduction to data processing
2. Computer operations
3. Introduction to programming

5. Resources for Curriculum Implementation

5.1 Faculty

Qualified faculty are needed to train data entry personnel and to effectively gear the data entry curriculum to the specific needs of the local community.

State or local governments regulate the hiring practices and qualifications of educational faculty. However, data entry faculty should have at least the following qualifications:

- An associate degree in data processing from an accredited college or university and two years wage-earning experience in data processing (preferably data entry)

or

- A high school degree or its equivalent and five years of wage-earning experience in data processing (preferably data entry).

5.2 Equipment

Because experience is a vital component of any data entry program, it is imperative that the data entry laboratory have sufficient numbers of key stations to accommodate all students. Ideally, one key entry device should be available for each student during any lab session.

The key entry devices need not be of the same type. For example, a laboratory for fifteen students might include a distributed data entry system with four stations, four key-to-diskette devices, five buffered keypunch machines, and two computer terminals. Such an environment would provide the students with experienced on many devices, but would also require careful scheduling of student access. The types of data entry equipment utilized in laboratory work should be determined by local job opportunities.

A person desiring information on the latest data entry equipment can use the names and addresses of vendors listed in periodicals such as Computer Decisions. A list of specific brands of data entry equipment is also given in Appendix B.2.

5.3 Advisory Committees

Many states require that technical programs have regular meetings of advisory committee made up of representatives from local industry. Regardless of state requirements, advisory committees are of the utmost importance in keeping the data entry program up to date and of relevance to the community. Such committees should meet at least once or twice annually and should be consulted on all hardware and program changes.

5.4 Instructional Aids

There are few textbooks on data entry or keypunching. See Appendix A.1 for those currently available and check with the publishers for revisions and new publications.

The periodicals listed in Appendix A.5 are excellent sources of the latest information on data processing and are highly recommended for all schools offering data entry programs.

Manuals describing the use of specific brands of equipment may be obtained directly from the manufacturers (see Appendix A.3) or their local sales or technical representatives.

Other instructional aids available for the teaching of data entry include audio-visual materials (Appendix A.2), exercises and programmed instruction books (Appendix A.4), and the articles and other references listed in Appendix A.6.

References

1. Awad, Eli M. and Data Processing Management Association, eds., "Trends in Data Entry and Output Devices," Issues in Business Data Processing, Part 3. Englewood Cliffs, NJ: Prentice-Hall, Inc., (1975).

2. Baker, Jerome D and others, "Operating Controls," Guidelines to Data Processing Management. Park Ridge, IL: Data Processing Management Association.

3. Bauch, James H., "Cut Input Costs with Key-to-tape Devices," Computer Decisions, Vol. 3, No. 5 (May, 1971), pp. 36-39.

4. Benwell, Nicholas J., Data Preparation Techniques Advanced. Advanced Publications Limited, Victoria House Printing Co., 48 San St., London England, (1976).

5. Bernstein, Robert S., "Terminal Overview '77, Remote Batch," Government Data Systems, Vol. 6, No. 2 (March/April, 1977), pp. 21-22.

6. Brandt, George, "Terminal Overview '77, Programmable," Government Data Systems, Vol. 6, No. 2 (March/April, 1977), pp. 22-23.

7. "Data Entry, Intelligent Terminals and OCR," (Excerpted from a DATAPRO 70 report), Computer Decisions, Vol. 9, No. 2 (February 1977), pp. 47-51.

8. "Data Entry Management Association 1979 Member Equipment Survey," DEMA Newsletter, Vol. 29, No. 5 (May, 1979).

9. Dyek, Freeman, "Automating the Data Entry Function Through Merging Technologies," Government Data Systems, Vol. 7, No. 5 (September/October 1978), pp. 18-22.

10. Gilb, Tom and Gerald Weinberg, "Humanizing Data Entry by Default," Datamation, Vol. 22, No. 8 (August, 1976), pp. 73-76.

11. Gilb, Tom and Gerald M. Weinberg, Humanized Input. Cambridge, MA: Winthrop Publishers, Inc., (1977).

12. Gilliam, Chuck, "Mobile Terminals in Patrol Cars Provide Instant Data for Police," Government Data Systems, Vol. 3, No. 1 (January/February, 1973).

13. Gray, Peter J., "Optical Readers and OCR," Modern Data, Vol. 4, No. 1 (January, 1971).

14. Hansen's Weber Salary Survey on Data Processing Positions, 1080 Green Bay Road, Lake Bluff, IL 60044.

15. Jackson, Scott, "Data Recorders: Still Best Data Entry Option for Many Applications," Data Management, Vol. 10, No. 12 (December, 1972), pp. 24-27.

16. Johnson, Mildred F., "Job Specifications for the Computer Production Operations and Skill-Related Data Processing Job Cluster." Ann Arbor, MI: University Microfilm International, (1976).

17. Kallis, Stephen A., "The Rise and Prospering of Data Terminals," Data Management. Vol. 14, No. 8 (August, 1976), pp. 17-18.

18. Klotz, William H., "Combining Data Entry with Dispersed DP," Data Management, Vol. 14, No. 10 (October, 1976) pp. 22-25.

19. Leslie, Joel and John Leighton, "Data Entry: Where It Stands Today," Government Data Systems, Vol. 5, No. 2 (May/June, 1976), pp. 26-27.

20. MacCormack, Robert D., "Evaluating Data Entry Systems," Data Management, Vol. 14, No. 10 (October, 1976), pp. 16-21.

21. Mandell, Mel, "A 'Natural Electronic Marriage' of Information Tools," The New York Times (July 9, 1978), p. F3.

22. McMullen, Dennis A., "Decentralizing Data Entry with OCR," Datamation, Vol. 22, No. 9 (September, 1976), pp. 140-147.

23. Merowit, Howard, and Samuel Soberanes, "POS and the Grocer," Computer Decisions, Vol. 5, No. 4 (April, 1973), pp. 30-32.

24. Occupational Outlook Handbook, 1976-77. U.S. Department of Labor, Bureau of Labor Statistics.

25. "OCR Scanning System Speeds Medicare Claims Processing," Government Data Systems, Vol. 2, No. 6 (November/December, 1972), pp. 6-7.

26. Pathways Through Data Processing: Data Entry. Cherry Hill, NJ: Management Information Corporation (1978).

27. People Side of Data Entry, Part I. Cherry Hill, NJ: Management Information Corporation (1978).

28. Pickens, Lawrence D., "Texas Junior College Data Processing Curriculum: A Report." Corpus Christi, TX: Del Mar College (1977) (mimeographed).

29. Reagan, Fonnie H., Jr., "Is the Keypunch Realy Obsolete?," Computer Decisions, Vol. 5, No. 4 (April, 1973), pp. 12-16.

30. Reagan, Fonnie H., Jr., "Should OCR Be Your Data Input Medium?," Computer Decisions, Vol. 3, No. 6 (June, 1971), pp. 19-21.

31. Resource Guide for Performance-Based Word Processing Instruction. College Park, MD: Department of Industrial Education, University of Maryland (1977).

32. Scarpa, Joseph A., "Terminals For Communication Operation," Data Management, Vol. 14, No. 6 (June, 1976), pp. 12-15.

33. Severino, Elizabeth F., "Distributed Processing," Computer Decisions, Vol. 9, No. 5 (May, 1977), p. 46.

34. Snyders, Jan, "Data Entry, Intelligent Terminals, and OCR," Computer Decisions, Vol. 9, No. 2 (February, 1977), pp. 38-46.

35. Thomson, Douglas H., "Terminal Overview '77, Teletypewriter-Compatible," Government Data Systems, Vol. 6, No. 2 (March/April, 1977), pp. 20-21.

36. Wohl, Amy D., "What's Happening in Word Processing?, Datamation, Vol. 23, No. 4 (April, 1977), pp. 65-72.

37. Woods, Mark, "Trend in COM is to User Convencience," Data Management, Vol. 14, No. 5 (May, 1976), pp. 29-31.

APPENDICES

The lists presented in the following appendices are not purported to be exhuastive. However, these lists should aid the data entry curriculum coordinator or instructor in developing, implementing, or updating the data entry curriculum.

APPENDIX A: REFERENCE MATERIALS

A.1 Textbooks

1. Blum, Jaime and Esther L. Blum, Keypunch, Keytape, and Keydisc. New York: Gordon and Breach (1975).

2. Bux, William E., Key-Punch Training Course. Cincinnati, Ohio: South-Western Publishing Co. (1969).

3. Buzby, Beth, Data Entry. Palo Alto, CA: SRA (1980).

4. Farina, Maria V. and Susan B. Sausville, Keypunching and Verifying. Reston, VA: Reston Publishing Co. (1973).

5. Hansen, Peggy, Keypunching. Englewood Cliffs, NJ: Prentice-Hall (1977).

6. Hansen, Peggy, Operating Data Entry Systems. Englewood Cliffs, NJ: Prentice-Hall (1977).

7. Keypunch and Verifier - Basic Data Processing Technology 8025.11. Miami, FL: Dade County Public Schools (1973).

8. Keys, William J., A Handbook of Modern Keypunch Operation. San Francisco: Canfield Press (1970).

9. Piesiale, Raymond F., Keypunch Training - A Student Text. Trenton, NJ: State Department of Education (1974).

10. Rosen, Arnold and Rosemary Fielden, Word Processing. Englewood Cliffs, NJ: Prentice-Hall, Inc. (1977).

11. Sorter and Advanced Keypunch - Basic Data Processing Technology 8025.12. Miami, FL: Dade County Public Schools (1973).

A.2 Audio-Visual Materials

Suggested sources of audio-visual materials for data entry are listed below.

	Source	Type of Material
1.	Deltak 9950 W. Lawrence Avenue Schiller Park, IL 60176	Data processing concepts for data preparation and control
2.	Educational Development Laboratories, Inc. Huntington, NY	Filmstrip course to improve keypunching speed & accuracy
3.	EDUTRONICS 3435 Broadway Kansas City, MO 64111	Buffered & unbuffered keypunch (IBM 029 & 129) No. 805.21, No. 805.20, No. 805.22
4.	Hoffman Occupational Learning Systems C/O Education Learning Systems of Texas P.O. Box 1012 Hurst, TX 76053	Cassettes & slides or film on: - Punched card No. 32-0201 - IBM 029 & 059 No. 32-0202 - UNIVAC 1710 No. 32-0203 - NCR 735 Tape Encoder No. 32-0204 - NCR 735 Operating Techniques No 32-0205
5.	Honeywell Information Systems 60 Walnut Street Wellesley Hills, MA 02181	Keytape Operator Training (P/I)
6.	IBM Corporation Customer Education 1133 Westchester Avenue White Plains, NY 10604	Unbuffered & buffered keypunch (IBM 029 & 129) No. 5B 0F2075
7.	Langford Publishing Co. P.O. Box 8711, Dept. N San Jose, CA 95155	A few transparencies on COMPUTER HARDWARE No. WC202TN
8.	Media Systems Corp. 757 Third Avenue New York, NY 10017	Tapes, slides, workbook on IBM 029
9.	Multimedia Division Melton Book Company 111 Leslie Street Dallas, TX 75207	Transparencies - Hollerith code, card types, card layout and design
10.	PAMI Learning Systems, Inc. Box 163 Collinsville, IL 62234	Buffered & unbuffered keypunch (IBM 029 & 129) - slides or filmstrips with audio cassette tapes

A.3 Manuals

1. *Honeywell 7/9 Channel Keytape Devices, Data Entry Hardware*, AC-91. Waltham, MA: Honeywell Information Systems (January, 1972).

2. *IBM 29 Card Punch Reference Manual*, A24-3332. White Plains, NY: IBM (August, 1968).

3. *IBM 129 Card Data Recorder/Machine Description*. GA22-6980. White Plains, NY: IBM (1973).

4. *IBM 129 Card Data Recorder Manual*, GA22-6968. Atlanta, GA: IBM (April, 1974).

5. *IBM 3740 Data Entry System Summary and Installation Planning*, GA21-0152. White Plains, NY: IBM (January, 1973).

6. *IBM 3742 Dual Data Station Operator's Guide*, GA21-9136. White Plains, NY: IBM (April, 1973).

7. *IBM 5496 Models 1 and 2 Data Recorder Operator's Guide*, GA21-9086, White Plains, NY: IBM (December, 1973).

8. *Mohawk Data Sciences 6400 Series Data-Recorders*, M-1758-1721. Herkimer, NY: Mohawk Data Sciences Corporation (1971).

9. *UNIVAC 1710 VIP Operator's Reference Manual*, UE-639. Princeton, NJ: Sperry/UNIVAC Computer Systems Education Center (1973).

10. *UNIVAC 1801 VP/1810 VIP Operator's Reference Manual*, UE-699. Princeton, NJ: Sperry/UNIVAC Computer Systems Education Center (1974).

11. *TAB Products 701/702 Operator Reference Guide*, TAB Products, Palo Alto, CA.

12. *TAB System 700 Operator Training Manual*, 0096-00, TAB Products, Palo Alto, CA.

13. *Concepts & Operating Techniques, 700 Data Entry System*, TAB Products, Palo Alto, CA.

    NOTE: The key-to-disk manuals exist in large number due to the many types of equipment. Some examples are:

14. Sperry UNIVAC 1900.10, UP-9101, UP-9103, UP-9102, UP-8150 Sperry UNIVAC, 7540 LBJ Freeway, Dallas, TX 75251.

15. NIXDORF 80 Series, SU-6801, SP-3821.01, SR-4804, NIXDORF Computer Corp., 168 Middlesex Turnpike, Burlington, MA 01803.

16. Four-Phase DATA IV Operator's Manual SIV/70-12-414 and Supervisor's Quick Reference Manual SIV 170-04-12C Four Phase Systems, Inc., 10700 N. DeAnza Blvd., Cupertino, CA 95014.

17. CMC Manuals, PERTEC Computer Corp., Computer Systems Div., 12910 Culver Blvd., P.O. Box 92300, Los Angeles, CA 90009.

18. IBM 5280 Series Manuals, IBM, 44 S. Broadway, White Plains, NY 10601.

A.4 Exercises and Programmed Instruction Books

1. *IBM 3742 Dual Data Station Basic Operation Training Student Study Guide*, GR 20-4371. White Plains, NY: IBM (June, 1974).
2. *IBM 3742 Dual Data Station Advanced Operation Training Student Study Guide*, GR 20-4372. White Plains, NY: IBM (June, 1974).
3. *1701 VP/1710 VIP Programmed Instruction for Experienced Alpha Numeric Keypunch Operators*, UE-630. UNIVAC/Sperry Rand Corp., (1972).
4. *1701 VP/1710 VIP Programmed Instruction*, UE-639. UNIVAC/Sperry Rand Corp., (1972).
5. *1801 VP, 1810 VIP Programming Course, UE-701*. Sperry-UNIVAC Computer Systems Education Center (June, 1974).
6. *1801 VP/1810 VIP Programmed Instruction Course for Experienced Operators of Buffered Keypunches*, UE-700. Sperry-UNIVAC Computer Systems Education Center (June, 1974).
7. *Operating the IBM 129 Card Data Recorder* (Study Guide with four cassettes), SR 20-4226. White Plains, NY: IBM (no date given).
8. Bux, William E. *Key-Punch Training Course*. Cincinnati, OH: South-Western Publishing Co., (1969).
9. Pactor, Paul and George Kargilis. *Card-Punch Machine Operation*, Books 1 and 2. New York: McGraw-Hill Book Co. (1968).
10. General Reference: *IBM Customer Education Catalog and Schedule*, G320-1244.

A.5 Periodicals

1. Computing Newsletter (monthly)
   Box 7345
   Colorado Springs, CO 80933

2. Computer Decisions (monthly)
   Hayden Publishing Company
   P.O. Box 8309
   Philadelphia, PA 19101
   (Free to educators--use form in magazine)

3. Computers and People (monthly)
   815 Washington Street
   Newtonville, MA 02160

4. Computerworld (weekly newspaper)
   797 Washington Street
   Newton, MA 02160

5. Data Management (monthly)
   Data Processing Management Association (DPMA)
   505 Busse Highway
   Park Ridge, IL 60068

6. Datamation (monthly)
   P.O. Box 200
   Greenwich, CT 06830
   (free to educators with letter written on company paper)

7. Data Entry Awareness Report
   Management Information Corp.
   140 Barclay Center
   Cherry Hill, NJ 08034

8. Data Entry Digest (bi-monthly)
   10522 Ridgeway Drive
   Santa Ana, CA 92705

9. Data Entry Management Association
   (DEMA) Newsletter (monthly)
   P.O. Box 3231
   Stamford, CT 06905

10. Government Data Systems (bi-monthly)
    United Business Publications
    750 Third Avenue
    New York, NY 10017

11. Infosystems (monthly)
Hitchcock Publishing Company
Hitchcock Building
P.O. Box 3007
Wheaton, IL 60187
(Free to educators and other qualified personnel)

A.6 Other References

1. Reference Books

a. Draper, A.M. Leslie, Career Guide for Entry Occupations. Los Angeles, CA: California Occupational Analysis Field Center (1973).

b. Resources in Vocational Education. Columbus, OH: The National Center for Research in Vocational Education.

2. Articles

a. Brown, Foster, "Distributed Processing/There Ain't No Free Lunch," Computer Decisions, Vol. 9, No. 4 (April, 1977), p. 46.

b. Cashman, Michael, "DP Salary Survey," Datamation, Vol. 23, No. 11 (November, 1977), pp. 114-136.

c. Chu, Albert L.C., "How to Cost-Justify COM," Infosystems, Vol. 19, No. 4 (April 1972), pp. 32-33.

d. Dorn, Philip H., "Whither Data Entry," Datamation, Vol. 19, No. 3 (March, 1973), pp. 49-51.

e. "Electric Funds Transfer Systems--An Overview," Data Management, Vol. 15, No. 3 (March, 1977), pp. 18-32.

f. Feidelman, Lawrence, "The New Look of Data Entry," Infosystems, Vol. 24, No. 12 (December, 1977), p. 46.

g. Feidelman, Lawrence, "A Perspective: Data Entry for Small Business Computers," Small Systems World (June, 1980), pp. 20-23.

h. Flato, Linda, "EFT and Crime," Computer Decisions, Vol. 7, No. 10 (October, 1975), pp. 30-33.

i. Granholm, Jackson W., "Alphanumeric Display Terminals," Datamation, Vol. 22, No. 1 (January, 1976), pp. 40-58.

j. Hansen, John R., "The DP Future of Word Processing," Infosystems, Vol. 25, No. 5 (May, 1978), pp. 74-76.

k. Heiker, Vince, "Going Cardless," Datamation, Vol. 22, No. 9 (September, 1976), pp. 151-154.

l. Kelly, Don, "In the Market for COM? Here's How to Buy," Data Management, Vol. 14, No. 5 (May, 1976), pp. 24-28.

m. Lasden, Martin. "Keep Your Data Entry Up To Date," Computer Decisions, Vol. 12, No. 4 (April, 1980), pp. 51-69.

n. Libby, Dr. Wilham H., "A Tale of Four COM Users and a Look into the Future," *Data Management*, Vol. 14, No. 5 (May, 1976), pp. 18-22.

o. Lusa, John M. "An Intelligent Approach to Data Entry," *Infosystems*, Vol. 26, No. 12 (December, 1979), pp. 42-47.

p. "Making the Case for Key-to-disk," *Computer Decisions*, Vol. 5, No. 4 (April, 1973), pp. 20-21.

q. Newton, Charles W. "Revealing DE Marketplace Survey," *Data Management*, Vol. 18, No. 2 (February, 1980), pp. 30-32.

r. "1981 Salary Report," *Infosystems*, Vol. 28, No. 6 (June, 1981), pp. 38-53.

s. Rhodes, Wayne L., "Information Processing Emerges From Integration," *Infosystems*, Vol. 26, No. 1 (November, 1979), pp. 36-38.

t. Rhodes, Jr., Wayne, "The Disproportionate Cost of Data Entry," *Infosystems*, Vol. 27, No. 10 (October, 1980), pp. 70-76.

3. Reports

a. *Business Education for the Seventies*. Springfield, IL: Office of the Superintendent of Public Inst. (1972).

b. *Guideline for Selection of Data Entry Equipment*, FIPS PUB 67, U.S. Dept. of Commerce/National Bureau of Standards. Springfield, VA: National Technical Informatjion Service (September, 1979).

c. *How to Select and Use Data Entry Devices*, Delran, NJ: Datapro (1978).

d. Leeson, Marjorie, "Behavioral Objectives for Delta College Data Entry Program." University Center, Michigan (mimeographed).

e. *People Side of Data Entry*, Part II. Cherry Hill, NJ: Management Information Corporation (1978).

4. Dissertations

a. Bucks, Jane A., "An Analysis of Data Processing Occupations," Doctoral Dissertation, Oklahoma State University (1972).

b. Lyon, Robert L., "A Determination of the Relative Importance of Tasks Performed in Selected Entry Level Data Processing Jobs in Texas with Curricula Implications," Doctoral Dissertation, Texas A & M (1973).

APPENDIX B. ENVIRONMENTAL CONSIDERATIONS

B.1 Specific Brands of Data Entry Equipment

1. Buffered Keypunches (data recorders)
   a. IBM 129 Data Recorder (Model 3 - the VIP)
   b. IBM 5496 Data Recorder (System 3 - the VIP)
   c. UNIVAC 1710 VIP
   d. UNIVAC 1810 VIP
   e. TAB 501 VIP
   f. Decision Data 8010 Interpreting Data Recorder

2. Key-to-tape devices
   a. Computer-compatible tape
      (1) IBM 50 Magnetic Data Inscriber
      (2) Mohawk Data Recorder 6400 Series
      (3) Honeywell Keytape, Models 700 & 900
      (4) Burroughs 7000N/9000N
   b. Cassette or cartridge tape
      (1) Data Instruments DATAPLEX
      (2) Digital Information Devices 3700 Series
      (3) Kearne Associates MINI-KEY
      (4) Singer 1500 systems

3. Key-to-diskette devices
   a. IBM 3741 and 3742
   b. TAB 701 and 702 (IBM 3741/3742 compatible)
   c. SYCOR 400 Series
   d. Mohawk Series 21
   e. CADO 40
   f. TI 774

4. Key to disk devices.
   See December issues of Data Entry Awareness Reports, User Survey:

5. Timesharing terminals.
   See list of terminal manufacturers given in Pathways Through Data Processing: Data Entry, (26: pp. 104-196).

B.2 Guidelines for Speed and Accuracy

1. Accuracy

Accuracy is singly more important than speed in a data entry environment. No matter which device is being used, the same accuracy requirements are recommended.

Grade	Percentage of strokes in error
A	.5% or less
B	between .5% and 1.5%
C	between 1.5% and 3%
D	between 3% and 6%
F	more than 6%

2. Speed

The type of machine being used and the data entry aids available will determine to a large extent the speed of the operator. However, the suggestions given below reflect entry of an average job with speed skills acceptable by the majority of data entry shops. The instructor is advised to check with industries in the local community for more applicable figures.

NOTE: In these guidelines, speed is measured in strokes per hour (sph)

a. Unbuffered Keypunch

Grade	Speed
A	11,000 sph or more
B	9,000 - 10,999 sph
C	7,000 - 8,999 sph
D	5,000 - 6,999 sph
F	less than 5,000 sph

b. Unbuffered Verifier

Grade	Speed
A	12,000 sph or more
B	10,000 - 11,999 sph
C	8,000 - 9,999 sph
D	6,000 - 7,999 sph
F	less than 6,000 sph

c. Buffered keypunch

Grade	Speed
A	12,500 sph or more
B	10,500 - 12,499 sph
C	8,500 - 10,499 sph
D	6,500 - 8,499 sph
F	less than 6,500 sph

d. Key-to-tape, key-to-diskette, key-to-disk

Grade	Speed
A	14,000 sph or more
B	11,500 - 13,999 sph
C	9,000 - 11,499 sph
D	6,500 - 8,999 sph
F	less than 6,500 sph

e. Timesharing terminal

Grade	Speed
A	12,500 sph or more
B	10,500 - 12,499 sph
C	8,500 - 10,499 sph
D	6,500 - 8,499 sph
F	less than 6,500 sph

APPENDIX C. VOCABULARY

access
accumulator
ALC
alpha
alphameric (alphanumeric)
APL
ASCII
BASIC
BCD code
binary
bit
block
buffer
byte
chaining
character
character reader
character set
check digit
COBOL
column
COM
communications (computer)
computer
console
control characters
controller
copies: hard, soft
coupler
CRT
cursor
data
data control
data entry
data set
default
density
digit punch
display
(source) document
(program) drum
EBCDIC code
EDP
EOD
EOF
extent
field
field length

file
fonts
FORTRAN
functional keys & control switches
format
hash total
hexadecimal
Hollerith code
Industrial data collection
input
interaction
interpret
jam
justify: left and right
key
key-to-cassette
label
left zero insertion
magnetic core
magnetic disk
magnetic diskette
magnetic tape
memory
MICR
microcomputer
minicomputer
mode
modem
Network
OCR
octal
offline; online
optical bar code
optical scanning
output
overwrite
parity
peripheral equipment
PL/1
pooler
port
portable data recorder
POS
printer
processing: batch and real time
program; program card
program control; program level
record; logical and physical record; inter-record gap (IRG)
remote job entry (RJE)
RPG

search
sector
significant digit
software/hardware
source document
status
tape mark (TM)
terminal: intelligent, dumb, programmable
timesharing
track (disk); 7 & 9 track tapes
TWX
verify
wand
word processing
wrap
X & Y punches/control punches
zero suppression
zone punch

APPENDIX D. STUDENT CLUBS AND DATE ENTRY ORGANIZATIONS

Organizations suitable for data entry students are:

1. Data Processing Management Association (DPMA). For information contact:

   DPMA
   505 Busse Highway
   Park Ridge, IL 60068

2. An Office Education Chapter (OEA). For information contact:

   Office Education Association
   1120 Morse Road
   Columbus, OH 43229

A new organization formed to help professionalize the work of data entry and make it more than just keypunch-supervisor work is:

Data Entry Management Association (DEMA)
P.O. Box 3231
Stamford, CT 06905
Phone: (203) 322-1166

This organization has regional meetings. It is attempting to fill the void left in data entry by the rapid growth of data processing.

APPENDIX E. APTITUDE TESTS

Computer Input Services, Inc.
6910 Market Street
Upper Darby, PA 19082

APPENDIX F. CONTRIBUTORS AND WORKSHOP PARTICIPANTS

1. The Atlanta, Georgia, February, 1977 Planning Session participants and visitors were:

Austing, Richard H., University of Maryland, College Park, MD
Beil, Donald, Rochester Institute for Technology, Rochester, NY
Caira, Priscilla, Whittier Regional Voc-Tech High School, Haverhill, MA
Cashman, Tom, Long Beach Community College, Long Beach, CA
Ciero, Richard, Thomas Nelson Community College, Hampton, VA
Charp, Sylvia, Philadelphia School District, Philadelphia, PA
Engel, Gerald L., Virginia Institute for Marine Sciences, Gloucester, VA
Gleason, Gary, Pensacola Junior College, Pensacola, FL
Kamerman, Dan, Robert J. Brady Co., Bowie, MD
Lee, Iva Helen, McLennan Community College, Waco, TX
Leeson, Marjorie, Delta College, University Center, MI
Lloyd, John (Jack), Montgomery College, Rockville, MD
Little, Joyce Currie, Community College of Baltimore, Baltimore, MD
Maniotes, John, Purdue University-Calumet Campus, Hammond, IN
Marcus, Robert, Ethnotech, Inc., Lincoln, NB
Meehan, Michael, Winthrop Publishers, Inc., Cambridge, MA
Seeds, Harice, Los Angeles City College, Los Angeles, CA
Shelly, Gary D., Anaheim Publishing Co., Fullerton, CA
Slocum, Richard, University of Maine at Augusta, Augusta, ME
Vernon, Erwin, Sinclair Community College, Dayton, OH
Weinberg, Gerald, Ethnotech, Inc., Lincoln, NB

2. The Gloucester Point, Virginia, August, 1977 Workshop Participants:

Austing, Richard H., University of Maryland, College Park, MD
Ciero, Richard, Thomas Nelson Community College, Hampton, VA
Dineen, John (Jack), Middlesex County College, Edison, NJ
Engel, Gerald L., Virginia Institute for Marine Sciences, Gloucester, VA
Hutcheson, Donna, East Texas State University, Commerce, TX
Lee, Iva Helen, McLennan Community College, Waco, TX
Leeson, Marjorie, Delta College, University Center, MI
Little, Joyce Currie, Community College of Baltimore, Baltimore, MD
Lloyd, John (Jack), Montgomery College, Crockville, MD
Plog, Claudia E. (Bette), El Centro College of the Dallas County Community College District, Dallas, TX
Ramach, Joseph, State of Maryland, Baltimore, MD
Seeds, Harice, Los Angeles City College, Los Angeles, CA
Stonebeck, John P., Northhampton County College, Bethlehem, PA
Sweeney, John, National Technical Institute for the Deaf, Rochester Institute of Technology, Rochester, NY
Vernon, Erwin, Sinclair Community College, Dayton, OH
Westley, John W., Illinois Central College, East Peoria, IL
Wood, Jacqueline A., University of Alabama, Birmingham, AL
Woodcock, Raymond W., Boulder Valley Voc-Tech Center, Boulder, CO

3. The Detroit, Michigan February, 1978 Workshop Participants:

   Austing, Richard H., University of Maryland, College Park, MD
   Ciero, Richard, Thomas Nelson Community College, Hampton, VA
   Engel, Gerald L., Virginia Institute for Marine Sciences, Gloucester, VA
   Hutcheson, Donna, East Texas State University, Commerce, TX
   Lee, Iva Helen, McLennan Community College, Waco, TX
   Leeson, Marjorie, Delta College, University Center, MI
   Little, Joyce Currie, Community College of Baltimore, Baltimore, MD
   Lloyd, John (Jack), Montgomery College, Crockville, MD
   Schrage, John, Southern Illinois University, Edwardsville, IL
   Seeds, Harice, Los Angeles City College, Los Angeles, CA
   Sweeney, John, National Technical Institute for the Deaf, Rochester Institute of Technology, Rochester, NY
   Vernon, Erwin, Sinclair Community College, Dayton, OH
   Woodcock, Raymond W., Boulder Valley Voc-Tech Center, Boulder, CO

4. We are also grateful to other persons and groups who have read drafts of the recommendations and given us their reactions. They are:

   Black, Earl, Texas Farm Bureau, Waco, TX
   Britton, Nancy, Texas Farm Bureau, Waco, TX
   Buzby, Beth, Jefferson State Junior College, Birmingham, AL
   Chadwick, Augusta, Los Angeles Trade-Technical College, Los Angeles, CA
   Charp, Sylvia, Philadelphia School District, Philadelphia, PA
   Conners, Karen, Rochester Institute of Technology, Rochester, NY
   Darnell, Jeannie, McLennan Community College, Waco, TX
   Education Committee, Data Entry Management Association, Stamford, CT
   Kite, R.M., Tulsa County Area Voc-Tech School District, Tulsa, OK
   Miller, Virginia, Texas Farm Bureau, Waco, TX
   Mladenka, Donnie, Citizen's National Bank, Waco, TX
   Moore, Ed, Hillcrest Hospital, Waco, TX
   Parker, David, Texas Farm Bureau, Waco, TX
   Pipkin, Lillian, Tyler Junior College, Tyler, TX
   Scardena, Paddy, El Centro College of the Dallas County Community College District, Dallas, TX
   Schleiff, Joe, Highland Community College, Freeport, IL
   Tuedio, James, Pasadena City College, Pasadena, CA
   Weinberg, Gerald, Ethnotech, Inc., Lincoln, NB
   Wohl, Amy, Datapro Research Corp., Delran, NJ

APPENDIX G. ACM COMMITTEE ON CURRICULUM FOR COMMUNITY AND JUNIOR COLLEGE EDUCATION, 1981

Chair: Joyce Currie Little, Community College of Baltimore, Maryland

Members: John (Jack) Dineen, Middlesex County College, Edison, New Jersey
Dennis Fletcher, Informatics, Inc., Canoga Park, California
Iva Helen Lee, McLennon Community College, Waco, Texas
Marjorie Leeson, Delta College, University Center, Michigan
John F. Schrage, So. Ill. Univ. at Edwardsville, Illinois
Harice Seeds, Los Angeles County College, California
John Sweeney, National Technical Institute for the Deaf, Rochester, New York
Erwin Vernon, Sinclair Community College, Dayton, Ohio
Ray Woodcock, Boulder Valley Voc-Tech Center, Boulder, Colorado

RECOMMENDATIONS AND GUIDELINES FOR A CAREER PROGRAM IN COMPUTER OPERATIONS

Abstract

This report offers recommendations and guidelines for a career program to educate computer operators for work in small, medium, and large scale computer centers. It represents the result of several years of effort by the Association for Computing Machinery's Committee on Curriculum for Community and Junior College Education, and is the consensus of a large number of computer educators and industry representatives.

These guidelines are applicable to programs in vocational-technical schools at all levels, community and junior colleges, and other post-secondary institutions interested in computer personnel for operations. They may be of use in evaluating existing programs or in establishing new programs.

The report provides objectives for a computer operations curriculum and gives a detailed topical outline for its implementation. It describes the different computer center environments in which operators work, and the functions of the various personnel who carry out the operation of the center. Recognition is given to the role operators play in the information system, the increasing number of responsibilities facing them, and the corresponding need to upgrade the status of their position.

Table of Contents

Page

0. Preface.. 65

1. Introduction... 66
    1.1 Computer Operations - Past, Present, and Future............ 66
    1.2 Purpose of the Report.................................. 68

2. Computer Operations Jobs: Prospects, Skills, and Environment.... 70
    2.1 Duties of the Computer Operator........................ 70
    2.2 Job Descriptions....................................... 71
    2.3 Job Environment.. 71
    2.4 Career Paths and Advancement........................... 72
    2.5 Employment Requirements................................ 73
    2.6 Qualities for Success.................................. 74

3. Objectives of the Computer Operations Curriculum................ 75
    3.1 Purpose of the Curriculum.............................. 75
    3.2 Performance Goals and Objectives....................... 75

4. Content of the Computer Operations Curriculum................... 78
    4.1 Computer Topics.. 78
    4.2 Related Topics... 90
    4.3 Instruction.. 91

5. Resources for Curriculum Implementation......................... 93
    5.1 Faculty.. 93
    5.2 Equipment.. 94
    5.3 Advisory Committees.................................... 95
    5.4 Instructional Aids..................................... 95
    5.5 Internships and Cooperative Work (Coop) Programs........... 95
    5.6 Career Guidance.. 96

6. Articulation... 97

References... 98

Appendices... 99

A. Reference Materials...................................... 100
    A.1 Textbooks.. 100
    A.2 Audio-Visual and Programmed Instruction Books.............. 100
    A.3 Operations Manuals..................................... 102
    A.4 Dictionaries and Glossaries............................ 102
    A.5 Periodicals.. 102

B. Existing Operations Programs............................. 104

C. Vocabulary... 106

D. Student Memberships...................................... 116

E. Aptitude Tests and Career References..................... 117

F. Definitions of Computer Operations Positions............. 118

G. Contributors and Workshop Participants................... 121

H. Committee on Curriculum for Community and Junior College Education, 1981... 124

Preface

This report was prepared by the ACM Committee on Curriculum for Community and Junior College Education, under the auspices of the Education Board of the ACM. Work has been coordinated by John V. Sweeney, National Technical Institute for the Deaf, with the assistance of Iva Helen Lee, McLennan Community College, Waco, Texas, Richard Walton, National Technical Institute for the Deaf, and Raymond Woodcock, Boulder Valley Vocational-Technical Center, under the direction of the Chair of the Committee, Joyce Currie Little, Community College of Baltimore, Maryland.

Efforts toward this report were initiated in August, 1977. After a concentrated session in August, 1978, a draft was produced. Reactions and responses from industry representatives were first obtained in an August, 1979 workshop. The resulting draft was circulated to more than 250 industry and educational representatives for their reaction before the final report was prepared.

Members of the Committee and the working group on computer operations would like to thank all those who made this report possible. The Committee would especially like to thank Dr. Gerald L. Engel, Christopher Newport College, Newport News, Virginia, who was Chairman of the ACM Curriculum Committee on Computer Education during most of the time of this work. We also would like to thank Dr. Richard H. Austing, University of Maryland, College Park, who was Vice-Chairman of the Education Board during most of this work, for his assistance in coordination and direction. We also thank Dr. William H. Atchison, University of Maryland, College Park, who was Education Board Chairman during most of this work, for his support and encouragement.

The Committee is grateful to all those persons who helped by contributing their comments, reactions, and advice. Many persons participated in workshops, others reviewed drafts of the manuscripts, and other referred us to sources of information. All those who contributed toward the report, including those who participated in our workshops, are named in Appendix G. Names of the Committee are given in Appendix H. Special thanks are sent to the National Technical Institute for the Deaf at Rochester Institute of Technology for their assistance with manuscript production, and to our editor, Maureen Shumate, for her work.

Special thanks also go to those publishers and authors who printed announcements and sponsored review articles.

We hope this work will be of benefit to the industry. ACM and the Committee would be pleased to hear how it has been of use to you.

1. Introduction

This report has been prepared for use by educational institutions such as community and junior colleges, vocational technical schools, and technical institutes. It is designed to help prepare entry-level computer operators for work in small, medium, and large computer centers.

The community and junior college philosophy - that the education provided by their institutions serve the community - is the foundation for this work. The Committee preparing this report feels that the entry-level operator must be prepared as far as possible to meet the needs of local industry, even though it is not practical to train each student on every type of machine used in the community. The entry-level computer operator must be prepared for continual learning to keep up with the rapid changes in the field. The operator must be able to use a problem-solving approach to ensure that necessary work is accomplished, deal with problems in the areas of privacy and security, and function ethically and morally in a complex environment. Finally, the Committee feels that the computer operator should be accorded the respect and salary commensurate with the responsibilities of the job, and should be able to progress upward in a career path within computer operations.

Preparing a curriculum that provides a core of basic technical information and at the same time prepares the student for work in a rapidly changing field is not easy. Few institutions even claim to incorporate both objectives in their data processing programs. As one writer has said, "There is a good deal of justification for the charge often made by EDP professionals that college EDP curriculums are generally unrealistic and do not reflect the needs of industry. Part of the problem is undoubtedly due to the sudden and rapid growth of these educational programs without proper time for planning goals or developing philosophies." (1) And so it is with computer operations. Very little has been produced to help institutions establish good programs for operator training. Very little is known about how many programs there are, or at what level. One major survey of courses offered in higher education did not gather data on operations courses. (3)

It is the intent of this committee to propose a viable curriculum for the teaching of computer operations--one that provides a framework on which colleges may build programs specifically suited to their own needs, rather than functions as a training program suited to a specific machine or specific environment. These recommendations could be used for establishing such a curriculum, or for evaluating existing ones.

1.1 Computer Operations - Past, Present, and Future

Past. Historically, data processing has been divided into two major areas: program development and operations. In recent years, considerable attention has been given to the program development group (especially programmers) regarding their education, careers, and status as professionals.

The need for more technically qualified people, combined with the shortage of suitable candidates has increased the salaries and professional status of programmers to very attractive levels. (4)

In the past, graduates of programming curriculums were often advised to accept any opening in the data processing field, with the understanding that the situation was temporary. They would start in operations, but move to programming as soon as possible, creating a perpetual migration. Unfortunately, the scarcity of trained personnel has not affected operators' salaries as it has programmers'. Nor have operators received the training and education accorded programmers: training and education for operators have been almost non-existent. What training there is has usually occurred on the job, at the hands of another operator. This "follow-me-around-and-do-what-I-do" type (4) of training reflects the present trend to educate operators on the job. Computer operations personnel have had perhaps less attention than other data processing people. Operations personnel often reach the top of their line and have little opportunity for promotion except for moving over into programming at an entry level, which often requires a temporary cut in pay. (2)

Present and Future. This unfortunate situation is just beginning to improve. A recent effort to assess the productivity of operations personnel was made by the U.S. Department of Agriculture. (14) Although this work originated from management's concern about staffing problems, this thorough analysis resulted in development of a career path for computer operators, improved performance objectives, improved work flow, and the initialization of a career mobility plan for operators. This effort resulted in improved motivation, better self appraisal by the shift teams and improved overall production in operations. With hardware and software becoming more and more sophisticated, data processing departments are now finding that what they need is the dedicated professional, one who looks at computer operations not simply as a stepping stone to programming or systems, but is trained to meet the challenge of a growing and dynamic profession.

Growth in all data processing fields has been rapid. The Bureau of Labor Statistics reported that employment opportunities in data processing would continue to increase through the 1980s. (10) Requirements projected at that time for computer operations personnel amounted to 275,000 workers in 1980, an 83% increase from 1970. And the trend is expected to continue, with the number of console and peripheral equipment operator's positions increasing 116% by 1990 (10).

The operator's job is changing too, becoming more demanding, requiring greater skills and more intensive training. Online systems and less expensive direct access and mass storage devices are rapidly reducing the operator's need to interface with hardware, thereby reducing the number of operations personnel required in most large installations, but increasing the skill level needed by those who remain. (4) An operator's duties may now include supporting such applications as telecommunications and remote job entry. The operator may be required to handle production schedules for batch-oriented, well-defined business disciplines such as accounting, inventory control, and sales reporting or to maintain historical data for government or business forecasting.

The operator faces challenges of other sorts as well. The growth and sophistication of computer crime places increased pressure on the operator to monitor informational security and watch for unauthorized uses of the system. And the increased interest in privacy of the individual places great pressure upon the computer operator to act responsibly in handling confidential information and to make sure that others in the job environment do the same.

This rapidly changing profession clearly needs individuals with a strong educational background and a diversity of learning that will bring state-of-the-art advances to computing centers. Once trained, the operator should not be required to leave that career to advance in salary or prestige. Instead, individuals should be selected for education and training from those who have the interest, aptitude, and responsibility. (2)

Some community and junior colleges have recognized the need for more formal training and are now offering courses or a certificate program in operations. A number of larger companies have devised in-house courses for training their operators, and some manufacturers of computer equipment have even developed mini-courses to familiarize operators with new equipment. (6, 7, 8) Despite recent progress, however, career planning for operations personnel has yet to extend much beyond the traditional path, from Operator C to Operator B to Operator A. As a result, some operators still look to programming for greater prestige and greater opportunities for advancement. To discourage the migration to programming, to enhance job satisfaction, and to promote computer operations as a vital professional career, operations must offer the same types of rewards as programming. The time has come to make a strong commitment to the training and education of operations personnel, to devise career paths that will stop the flow of skilled personnel away from operations, and to encourage more technically qualified people to enter the field. (4) Mutual effort on the part of operators, managers, and educators, in a properly planned and implemented institutional curriculum, is needed to accomplish this.

1.2 Purpose of the Report

In recognition of the conditions mentioned above, this report was written with the following objectives in mind:

1. To provide nationally recognized and accepted guidelines for the education of computer operations personnel that will meet the requirements of business and industry.
2. To offer advice for the establishment of new programs and courses in computer operations.

3. To encourage the revision of existing courses and programs in computer operations.

4. To advance the professionalism of the computer operator.

5. To encourage the establishment of, and viability of, a distinct career path in computer operations with potential for advancement, recognition, and success in the field.

6. To provide institutions with information about resources necessary for a computer operations program to be successful.

7. To identify techniques found useful in the teaching of computer operations.

8. To recommend that ways be found to monitor changing community needs and keep faculty and curriculum up to date.

2. Computer Operations Jobs: Prospects, Skills, and Environment

2.1 Duties of the Computer Operator

Although descriptions of specific computer operations jobs are available, the exact duties of an operator depend greatly on the size and type of the computer system, the purpose of the computer center and the number of people working there, and the type of industry and the area in which it is located. Some operators might work on only a small, stand-alone system, an online inquiry system, or a remote batch job entry system; others might work in a nuclear power plant, a large government computer center, or a small hospital. All of these jobs are different and require different skills and training.

Since computer operations jobs vary greatly, it is difficult to identify specific job-related duties. However, any person applying for an entry-level position as a computer operator must be prepared to accept the following responsibilities:

1. Develop and maintain the knowledge necessary to efficiently operate and recognize malfunctions of the computer and its peripheral components.

2. Develop and maintain sufficient knowledge of operating systems to be able to:

    a. Understand and efficiently act on console messages.
    b. Prepare job control changes within the job control environment.
    c. Operate efficiently and with limited supervision in both single and multiple jobstream processing.

3. Develop and maintain a knowledge of software uses, runbook specifications, and job control statements that will facilitate efficient operation.

4. Develop and maintain a basic knowledge of all systems as they affect operating conditions.

5. Perform required assemblies, compiles, and tape and disk updates by using appropriate software.

6. Process tests from programmer's instructions and document the results, including problems and observations.

7. Maintain a set of files and supplies for easy access to minimize delay between production runs.

8. Remove write rings from tape files when necessary to prevent destruction of permanent data and ensure that protect switches are on during tape and disk processing; prepare labels and storage records for tape and disk files according to instructions and schedules; and exercise proper care in the handling and mounting of tapes and disks to ensure maximum operating efficiency, prevent physical damage to tapes and disk, prevent physical damage to tape and disk drives, and prevent destruction of recorded input/output data.

9. Perform the steps needed to control data flow to and from the computer.

10. When necessary, operate either online or offline data entry equipment. (11, 9)

2.2 Job Descriptions

Descriptions of computer operations positions are published periodically in Datamation, Infosystems, and the Occupational Outlook Handbook and "Hansen's Weber Salary Survey on Data Processing Positions". (5) Appendix F provides descriptions of computer operations jobs that closely parallel those given by Hansen.

2.3 Job Environment

Although many configurations of equipment exist, distinctions are most obvious between small and large systems. Small-system configurations typically include a CPU, disk storage, a diskette drive or a card reader, a display station, and a printer, whereas large configurations typically include a CPU, direct access devices (disk, etc.), sequential mode access devices (tape), a console, a card reader/punch, and a printer. Both configurations support multiprogramming capabilities, spooling and queuing, central or remote processing, and security devices to protect files and libraries.

The duties of an operator in a small shop, where only a few staff are available, may differ a great deal from those in a large shop. The small-shop operator is often required to perform a wider range of activities and thus needs to be more versatile. The small-system operator needs:

- operations skills
- some data entry skills, including some production data entry
- understanding of data control and scheduling techniques
- some programming skills
- some understanding of systems analysis and design
- ability to document
- some understanding of business systems such as accounting.

The large-system operator is more of a specialist, usually concentrating on one or a small group of functions such as the following:

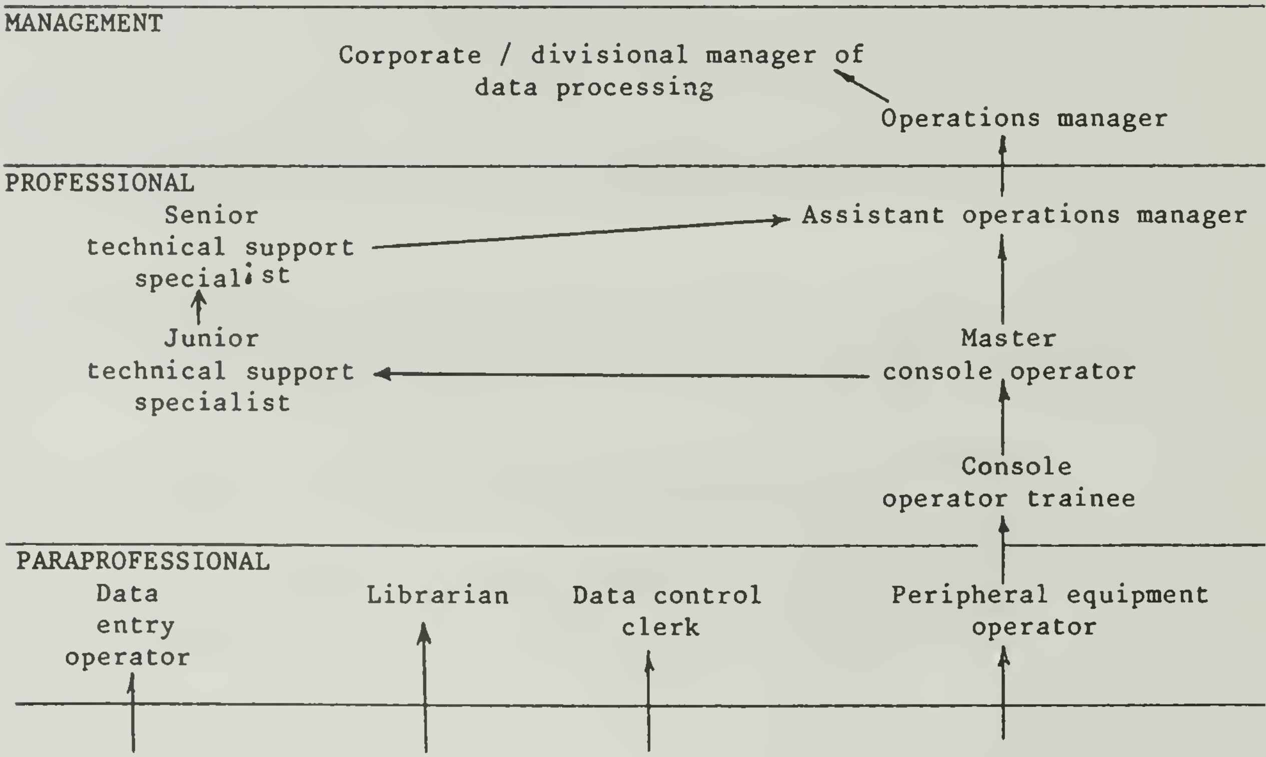
- console operations
- peripheral equipment operations
- support services
- data control
- scheduling
- data entry
- overseeing other personnel
- documentation
- data communications

2.4 Career Paths and Advancement

Today's operations jobs are challenging and demanding. Operators probably spend 90% of their time interfacing with software (4). In the committee's opinion operators often are required to have a complete command of the complex job control language (JCL). They often control millions of dollars worth of hardware and are also responsible for security.

Operators must be highly trained for their work and adequately compensated for it. In addition, there must be some way for operators to advance or they will move to other fields. Planned career routes that encourage trained operators to remain in operations should therefore exist in every organization.

Figure 1. Large center career path. (A modification of Hansen's Chart (4))


MANAGEMENT
Corporate / divisional manager of data processing
Operations manager
PROFESSIONAL
Senior technical support specialist
Assistant operations manager
Junior technical support specialist
Master console operator
Console operator trainee
PARAPROFESSIONAL
Data entry operator
Librarian
Data control clerk
Peripheral equipment operator

Career paths for computer operators will differ in large and small computer centers. Figure 1 shows how a person might enter computer operations in a large center and progress upward while still remaining in the field. Note that a person might begin as a peripheral equipment operator, but might also begin as a data entry operator, librarian, or control clerk.

The path might diverge after the master console operator level. An experienced console operator with an excellent grasp of JCL and operating systems could certainly with additional training, advance to a technical support specialist in systems. (4) As a technical support specialist, the former operator would:

- be called first to correct JCL errors on abnormal terminations, contacting the programmer if necessary
- be responsible for program libraries and JCL procedure libraries
- write JCL for programmers
- monitor utilization and error reports
- perform system maintenance
- help the master console operator diagnose and correct operating system related errors
- assist in selection and installation of equipment
- perform system generation

In fact, becoming a technical support specialist is an excellent way for an operator in a large center to advance and yet remain close to operations. It also provides an alternative to the usual "management" route upward.

Working in a small center affords a different career prospectus. The small-system operator performs a variety of jobs and may act as operator, technical support specialist, and operations manager at the same time. With such a variety of experience, the operator may become proficient enough to pursue a more specialized, higher paying job.

Operators need not have applications or systems programming as their only career paths. The operator can carve out a career within operations, growing as the company grows, by becoming a technical user consultant/troubleshooter, shift manager, or production manager.

2.5 Employment Requirements

Entry-level placement in operations jobs usually requires that operators complete a probationary period at a level lower than their job expectations. This is usually done to determine stability of the candidate. Entry-level operators can expect shift work, with on-the-job training done on a specific machine under the supervision of an experienced operator. In large centers, on-the-job training is usually followed by assignment to night shifts for long periods.

Entry-level operators can also expect to handle large boxes of forms, which requires some physical strength. In the past, the strength requirement and concern for safety on the night shift were cited most frequently as reasons for hiring men rather than women. In view of recent emphasis on equal opportunity, women have proved to be capable of doing the work and men to be equally deserving of safe working conditions. Companies should concentrate on finding the right person for the job and then for ensuring that the working environment is suitable for all.

2.6 Qualities for Success

Jobs in operations are available to a variety of individuals, including those with certain handicaps. However, anyone seriously considering operations as a career should have the following attributes: a high degree of reasoning ability, manual dexterity, alertness, ability to concentrate, concern with detail, concern for accuracy and precision, and patience.

Some companies have developed aptitude tests for prospective employees; one is specifically suited for operators (see Appendix E). However, most companies prefer other ways to screen prospective personnel. A recent study in Dallas, Texas showed that 86% of the 22 companies surveyed did not use special aptitude and interest tests for screening applicants, but rather placed emphasis on experience, knowledge, and the ability to communicate effectively. (12)

3. Objectives of the Computer Operations Curriculum

3.1 Purpose of the Curriculum

The ultimate goal of the proposed curriculum is to produce computer operators fully trained to meet the needs of their communities, fully prepared to adapt to changing technologies, and fully aware of their value to industry. To this end, the computer operations curriculum has been designed to meet the following objectives:

1. To provide the technical skills necessary to qualify students for positions in the field of computer operations.

2. To develop an in-depth awareness and appreciation of computer operations as a professional career in itself.

3. To develop the operator's capability to function in different computer environments.

4. To provide a broad base for continued development and education.

5. To provide for personal and social growth and the development of communication skills needed to function in a business environment.

3.2 Performance Goals and Objectives

The computer operations curriculum has been designed so that the student will acquire skills in six major areas: hardware, software, and related operations, as well as business, personal/social development, and communication. It is therefore the intent of this curriculum that upon completing the program, the student will have fulfilled the following goals:

1. Hardware. An operator will have developed an in-depth understanding of the major hardware components of the computer system and other related equipment. Specifically, the student will be able to:

   a. Operate and control a computer system and its associated peripheral devices.
   b. Operate offline equipment normally considered part of the operations environment.
   c. Identify and respond to systems communications, including determination of data recovery points and rerun procedures.
   d. Perform basic maintenance on the equipment in the operations area.

2. Software. An operator will have developed an in-depth understanding of the major software components of the computer system. Specifically, the student will be able to:

a. Use manufacturer-supplied JCL and set up input/output utility programs.
b. Organize job flow to maximize efficient use of computer resources.
c. Demonstrate an understanding of the operating system by:
   - Readying the system for processing.
   - Reallocating system parameters as required.
   - Interpreting system messages and taking appropriate action.
d. Understand the concepts of at least one business-oriented programming language.
e. Understand methods of file organization and processing.
f. Understand commonly used business information systems (payroll, etc.) and how data flows through systems of programs (edits, updates, etc.).

3. Additional Operations Skills. An operator will have acquired additional skills in associated areas of data processing. Specifically, the student will be able to:

a. Compare the various jobs in the computer operations department and identify the responsibilities associated with each.
b. Perform proper media handling, storage, and labeling techniques.
c. Use reference manuals, documentation, and other support materials.
d. Perform data entry, data control, scheduling, and operational duties as directed.
e. Understand the need for and be able to use common procedures for computer recovery, and backup.
f. Understand security requirements.
g. Maintain a proper computer room environment.
h. Maintain the privacy of the data.
i. Identify and discuss the implications of such concepts as: spooling, teleprocessing, remote job entry (RJE), virtual storage, data base, multiprocessing, multiprogramming, etc.
j. Apply education to on-the-job training experiences.

4. General Business. An operator will have developed an increased awareness of the general business organization and its related work flow. Specifically, the student will be able to:

a. Demonstrate professional attitudes and acceptable work habits in the business environment.
b. Apply general business skills to different operational environments.
c. Evaluate computer output in terms of the application.
d. Recognize the necessity for good record keeping and documentation.
e. Analyze the role of the computer in general business systems.

5. Personal and Social Development. An operator will have developed an increased awareness of the need to maintain professional attitudes and ethics in the working environment. Specifically, the student will be able to:

  a. Appreciate the operator's responsibilities in the areas of data security, integrity, and privacy.
  b. Work within a team environment.

6. Communications. An operator must have good oral and written communications skills. Specifically, the student will be able to:

  a. Use appropriate technical terms to communicate with others.
  b. Read operations documentation and manuals.
  c. Prepare operations documentation, daily logs, and exception reports.
  d. Provide accurate communication about events in the computer operations area.

4. Content of the Computer Operations Curriculum

The curriculum consists of a core of computer-related topics, one set of which the committee feels to be essential in preparing students for a career in computer operations, the other set comprising optional topics that can be tailored according to the specific needs of the institution. Also recommended as part of the curriculum are courses in communication and business, subjects not directly related to computer operations but nonetheless vital in preparing students for work.

4.1 Computer Topics

4.1.1 Required topics. The required computer-related topics (see Table I) are presented in modular form, with each logical set constituting a unit. Units I, II, and II are introductory; Unit IV discusses the CPU. Units V through X each focus on a particular I/O device, each unit focusing on a specific I/O or storage device, with emphasis on operating procedures. Units XI through XIII concern communication and interface hardware, the computer facility, and operating systems and job control, respectively. The remaining three units concern other facets of computer operations, namely, computers in the organization, documentation, and the computer operations profession. The committee recommends Units I, II, III, IV, XV, and XVI be placed in all curricula with other device-independent units such as Units V through XI added according to the needs of the local job market. For example, an institution serving mostly small card-oriented shops would include Unit V and VI.

The topics are arranged in what the Committee feels to be a logical sequence based on their teaching experiences. It is not necessary that the units be taught in exactly this sequence, however. For example, the introductory units and the CPU unit might be taught as a 2-hour introduction to computer operations (or might even serve as the introductory course in data processing for some colleges). Units XI through XVI might be taught as intermediate or advanced topics in computer operations, with the "device" units taught as lab units in groups of three or four. We would like to emphasize, however, that exactly how these required topics are implemented must depend on the specific needs of the college.

Table I. Required computer topics.

Unit I: Background for Computer Operations

- A. Components of a data processing system
- B. History and development of today's systems
  - 1. Early history
  - 2. Unit record and punched card operations
  - 3. First three computer generations
  - 4. New developments
    - a. Minicomputers
    - b. Microcomputers
    - c. Business systems
    - d. Data communications
    - e. Distributed data processing

Unit II: Overview of Computer Operations' Function

- A. The data processing department
  - 1. Organization and areas
  - 2. Responsibilities of each area
  - 3. Flow of data
- B. Areas in computer operations
  - 1. Data entry
  - 2. Scheduling
  - 3. Data control
  - 4. Librarian function
  - 5. Documentation
  - 6. Computer operations
- C. Tools of the operator
  - 1. Computer manufacture reference manuals
  - 2. Installation reference manuals
  - 3. Run manuals
  - 4. Logs
  - 5. Standards manuals

Unit III: Principles of Data Processing

- A. Software development
  - 1. Programming languages
  - 2. Program execution
  - 3. Operating systems
  - 4. Utility programs
  - 5. Multiprogramming
  - 6. Common software packages (payroll, accounting, inventory, etc.)
- B. Data handling
  - 1. Types of file organization

        - a. Sequential
        - b. Indexed (ISAM and VSAM)
        - c. Direct
    - 2. Types of processing
        - a. Batch
        - b. Random
        - c. Real-time
    - 3. Problem areas in processing
        - a. Timeliness
        - b. Accuracy
        - c. Completeness
    - 4. Security
        - a. Data confidentiality
        - b. Access limitations
        - c. Security equipment (fireproof safes, etc.)
        - d. Backup
        - e. External and internal labels, passwords
    - 5. Data bases
- C. Hardware maintenance

Unit IV: The Central Processing Unit (CPU)

- A. System structure
    - 1. Data flow
    - 2. Console file and microprogram
    - 3. Control storage
    - 4. Main storage characteristics
    - 5. Registers
    - 6. Channels
    - 7. Number systems
- B. CPU characteristics
    - 1. Instruction sets available
    - 2. CPU facilities (time-of-day clock, etc.)
    - 3. Machine check handling facilities
- C. Channel characteristics
    - 1. Selector channels
    - 2. Multiplexor channels
    - 3. Bus structures
    - 4. Channel-less CPUs
- D. Console system control devices
    - 1. Lights and switches
    - 2. Power on and off procedures
- E. Multiple and attached processor configurations

Unit V: Card Readers, Punches, and Multifunction Card Devices

- A. General characteristics
    - 1. Physical properties of the medium
        - a. Codes used (Hollerith, BCD, binary, etc.)
        - b. Terminology used (9-edge, read check, punch check, etc.)
    - 2. Physical properties of the unit

B. Types of card devices
   1. Card reader
   2. Card punch
   3. Multifunction
C. Advantages and disadvantages of cards and card devices
D. Operating procedures
   1. Normal
      a. Card handling
      b. Proper storage procedures
      c. Console messages and procedures
      d. Stacker selection
   2. Error
      a. Recognition of card-related problems
      b. Handling of card-related problems
   3. Maintenance
E. Operational aids
   1. Utility programs
   2. Manuals

Unit VI: Printers

A. General characteristics
B. Types of printers
C. Advantages and disadvantages of hard copy
D. Operating procedures
   1. Normal
      a. Mounting forms
      b. Proper storage procedures
      c. Console messages and procedures
      d. Carriage control
      e. Replacement character set
   2. Error
      a. Recognition of printer-related problems
      b. Handling of printer-related problems
   3. Maintenance
E. Operational aids
   1. Utility programs
   2. Manuals

Unit VII: Tape Drives

A. General characteristics
   1. Physical properties of the medium
      a. Terminology
      b. Codes used
      c. Internal and external labels
      d. Data storage
      e. Density
      f. Recording (NRZI/phase-encoded)
      g. Physical properties of the unit

B. Types of tape drives
C. Advantages and disadvantages of tapes over other media
D. Operating procedures
    1. Normal
        a. Mounting tapes or cartridges
        b. Proper tape storage and handling procedures
        c. Console messages and procedures
    2. Error
        a. Recognition of tape-related problems
        b. Handling of tape-related problems
    3. Backup and security
    4. Maintenance
E. Operational aids
    1. Utility programs
    2. Manuals

Unit VIII: Direct Access Storage Devices (DASDs): Disk Drives

A. General characteristics
    1. Physical properties of the medium
        a. Terminology (tracks, overflow, sectors, cylinder, etc.)
        b. Codes used
        c. Internal and external labels
        d. Data storage
        e. Density
    2. Physical properties of the unit
B. Types of disk drives (removable, non-removable, data modules, etc.)
C. Advantages and disadvantages of disk
D. Operating procedures
    1. Normal
        a. Mounting disks
        b. Proper disk storage and handling procedures
        c. Console messages and procedures
    2. Error
        a. Recognition of disk-related problems
        b. Handling of disk-related problems
    3. Backup and security
    4. Maintenance
E. Operational aids
    1. Utility programs
    2. Manuals

Unit IX: Other DASDs

A. Diskette units
    1. Properties of the medium
        a. Terminology used (tracks, sectors, etc.)

        - b. Internal and external labels
        - c. Handling and storage
    - 2. Properties of the drive
        - a. Controls and lights
        - b. Operating procedures (normal and error)
        - c. Maintenance
    - 3. Operational aids
- B. Mass storage system (MSS)
    - 1. Advantages and disadvantages over more traditional DASDs
    - 2. Components of the system and their functions
        - a. Mass storage control (MSC)
        - b. Data recording control
        - c. Data recording device
        - d. Cartridge store
        - e. Staging adaptor
    - 3. System operation
        - a. Microcode for mass storage control, cartridge store, and staging adaptor (2a, 2b, and 2e above) and its functions
        - b. Loading the microcode
        - c. Commands and orders
        - d. MSC message handling
        - e. Error recoveries
- C. Data Cell
    - 1. Properties of the medium (cells, subcells, strips, etc.)
    - 2. Advantages and disadvantages over more traditional DASDs
    - 3. Operating procedures
        - a. Data cell removal and replacement
        - b. Data cell storage procedures
        - c. Ballast cell
        - d. Properties of the drive
        - e. Console messages and procedures (normal and error)
        - f. Maintenance
- D. Drum
    - 1. Properties of the medium (tracks, etc.)
    - 2. Advantages and disadvantages over more traditional DASDs
    - 3. Operating procedures
    - 4. Console messages and procedures
    - 5. Maintenance

Unit X: Console System Control Device

- A. General characteristics
    - 1. Types of console devices
    - 2. Physical characteristics of the device

        3. Primary, secondary, and maintenance consoles
- B. Operating procedures
    - 1. Normal
        - a. Setup procedures (forms and ribbon handling)
        - b. Keyboard handling (typing)
    - 2. Errors
        - a. Recognition of console-device-related problems
        - b. Handling of console-device-related problems
- C. Operational aids
    - 1. Manuals
    - 2. Lights
    - 3. Dials and switches

Unit XI: Data Communications, Teleprocessing, and RJE Hardware

- A. Modems
- B. Multiplexors
- C. Transmission links and methods
- D. Terminals
    - 1. Dumb
    - 2. Smart
    - 3. Intelligent

Unit XII: Computer Facilities and Control

- A. Characteristics
    - 1. Storage areas
    - 2. Raised floors
    - 3. Access limitations
    - 4. Structural security
    - 5. Environmental considerations
    - 6. Power and power supplies
    - 7. Efficiency maximization
- B. Resource control
    - 1. Standardized inventory procedures
    - 2. Security equipment procedures

Unit XIII: Operating Systems and Job Control

- A. Definition and purposes
- B. Features
    - 1. Supervisor or monitor
    - 2. Job control program
        - a. Definition of job control
        - b. General command formats available
        - c. General syntax
        - d. Specific commands and options
    - 3. Partitions and multiprogramming facilities

4. Spooling facilities
    a. Types
    b. Job control format for type used
    c. Commands and options for type used
5. System control panel (console) and console device
    a. Overview of keys and lights
    b. System preparation
        (1) IPL (Initial Program Load)
        (2) Initialization and termination of jobs
        (3) Support programs
    c. Console procedures
        (1) Manual intervention (clearing storage, etc.)
        (2) Canceling job prior to and during execution
        (3) Unusual situations (loops, hardwaits, power loss, etc.)
        (4) Spooling procedures (releasing, deleting jobs)
6. Interrupts
7. Software features
    a. Compilers
    b. Utilities/service programs
    c. Data management facilities
    d. Library management and maintenance facilities
    e. Job accounting and scheduling systems

Unit XIV: Computers in the Organization

A. Data processing within an organization
    1. Flow of computerized data through an organization
    2. Typical major user applications (examples are accounting and inventory systems)
    3. Social impact of the computer
        a. Job security
        b. Conformity and dehumanizing of jobs
        c. The possibility of complete dependency on computerized data
        d. The problem of incorrect computerized data
B. Organization of data processing services
    1. Structures of the data processing department
    2. Systems analysis and design
    3. Programming
    4. Operations
        a. Computer machine operation
        b. Control and scheduling
        c. Support services
            (1) Documentation
            (2) Ancillary machine operations
            (3) User assistance

        - d. Data entry
        - e. Cost allocation of data processing services
- C. Staff functions in operations
    - 1. Definition of responsibilities
    - 2. Organization of work to best serve the total organization, considering these conflicting demands:
        - a. Obtaining maximum throughput
        - b. Meeting the completion times required by the user
        - c. Successfully processing the jobs
        - d. Completing all necessary operator reports
        - e. Monitoring job processing activities
        - f. Maintaining a clean and orderly work environment
        - g. Evaluating productivity/performance measuring and evaluating productivity
    - 3. Identification of normal versus abnormal performance of the computer
    - 4. Appropriate handling of problems resulting from abnormal performance
    - 5. Provision of job status information on a timely basis
    - 6. Assistance to help users to realize maximum benefit from their computerized work

Unit XV: Documentation

- A. Functions of documentation
- B. Methods of documentation
- C. Types of documentation
    - 1. Applications systems documentation
        - a. Standard symbols and conventions
        - b. Case studies in systems documentation
            - (1) Effects of abnormal performances on subsequent processes
            - (2) Recovery procedures
        - c. Relationships between operator procedures and systems documentation
    - 2. Reference manual usage
        - a. Manufacturer manuals
        - b. Run manuals
        - c. Standards manuals
    - 3. Departmental record keeping
        - a. Data control
            - (1) Purpose
            - (2) Types
        - b. Scheduling
    - 4. Computer-produced documentation
        - a. Computer log
        - b. Trouble log

        - c. Backup records
        - d. Librarian records (tape, disk, etc.)

Unit XVI: Computer Operations Profession

- A. Work environment
- B. Work Performance and Productivity (standards for measuring quantity and quality of work)
- C. Career paths and opportunities
- D. Professional ethics
- E. Need for continued education

4.1.2 Optional Topics. The topics covered in the previous section are recommended as a minimum for institutions wishing to offer basic training in computer operations. Institutions with limited resources may find it necessary to limit their offerings to the required computer-related topics. However, the Committee feels that, wherever possible, courses be added to the basic curriculum that will enhance the student's understanding of computers, the way in which they function, and their uses in a world of expanding technology. Such courses can be fashioned from the topics below, tailoring each according to their resources and the needs of the communities they serve.

Minicomputers and microcomputers. The mini/micro revolution has reached us all, putting some type of computing capability in virtually every American household. For this reason, "mini/microcomputers" belongs high on the list of topics recommended for computer operators. A course on the subject should include:

1. Definitions
2. Types related to applications (home computing, business record keeping, multi-user)
3. Typical hardware configurations
    a. Memory systems
    b. Keyboards
    c. Video display
    d. Printers
    e. Tape cassettes and diskettes
    f. Telecommunications
    g. Plotters
4. Software

Programming. Knowing how to program is not required for someone to operate a computer. However, a general understanding of programming languages is certainly valuable to the operator, giving greater insight into the workings of the computer and enhancing credibility when dealing with systems or programming personnel. A course on programming concepts for the computer operator might typically include learning the commands and general structure of one of the most widely used languages (e.g., RPG-II, BASIC, COBOL, FORTRAN, Pascal).

Data communications and teleprocessing. Topics covered in a course on data communications and teleprocessing should include:

1. The communications channel
    a. Analog and digital transmission
    b. Purpose of modems
    c. Transmission rate categories (sub-voice, etc.)
    d. Private and leased lines
    e. Transmission line classes (simplex, etc.)
    f. Carriers available (TELEX, WATS, etc.)
2. Modems
    a. Modulation and demodulation
    b. Acoustical couplers
    c. Bauds
3. Characters and codes
4. Modes of transmission
5. Line errors: detection and correction
6. Network structures
    a. Types of switching
    b. Risks
    c. Polling
7. Implications related to data entry and distributed processing
8. Software

System analysis and design. Topics covered in a course on system analysis and design should include:

1. Objectives of system analysis
2. Tools for the systems analyst
    a. Organization charts
    b. Flowcharts and decision tables
3. Problem analysis
    a. Desired output
    b. Analysis of required input, including data formats and design
    c. Required processes, including evaluation of alternative methods
4. Basic system layout conventions
5. Documentation standards
6. Implementation and planning
7. Testing
8. Review processes

4.2 Related Topics

Graduates of a computer operations program must not only be skilled technically, but must be able to use communication skills and related talents to work in an organization responsibly, effectively, and productively. Subject matter must therefore include material that will enable the student to communicate effectively, both orally and in writing, and to understand organizational matters and information flow within a company.

4.2.1 Communication. The importance of speaking and writing proficiently is recognized in both academic and professional spheres. Business and industry representatives have declared these abilities to be as important as technical skills. Graduates must work closely with data processing personnel and communicate effectively with them. They must be able to keep records of the problems they encounter so that other personnel can understand and begin to solve these problems, and be able to use reference manuals effectively. They must be able to perform tasks that are described orally or presented in the form of flowcharts, written sequential lists, written instructions, or interactive computer displays. They must also be able to describe the status of jobs by using forms provided by the installation. And for professional growth and life survival, they should be able to write a resume, complete work applications, and conduct themselves creditably in interviews. Therefore, courses such as grammar, composition, technical writing, and speech should be part of the curriculum.

However, it is not enough that students simply take classes in communication. Writing and other communication skills must be emphasized in every course in the program, with computer-related courses building upon and strengthening those skills. Writing instructions and interpreting other's instructions should be part of student practice. Students should use these skills in all classes, just as they will on the job.

4.2.2 Business. The computer operator should be acquainted with certain fundamentals of business and economic systems, especially as practiced in the local community. Knowledge of the functions of a commercial organization and a comfortable use of its vocabulary are important. Skills needed in this area are often acquired by taking an existing introductory business course. Courses in supervision and management frequently develop insight into the interpersonal relationships of work situations. Also important for life survival are courses that teach personal finances, time management, business ethics, and skills related to professional growth.

It is important to include, as examples in computer-related courses, applications from the world of business. Typical business applications should be chosen for use in laboratory projects. These should be exercised thoroughly to ensure that the student understands both the application and the processing involved.

4.3 Instruction

Successful teaching requires two things, basically: motivating the student to learn and providing the means by which learning can best occur. This is true no less for the teaching of computer operations than for any other subject.

To learn effectively, students of computer operations must be made to feel that the career they've chosen is worthwhile, in terms of potential for personal growth and monetary gain and in the value of their profession to industry. They must also be part of a program that provides positive, relevant classroom experience geared toward attaining success in their career. Such a program can be achieved by providing extensive hands-on training, using a problem-solving approach in the classroom, and employing other techniques proven to be effective in the teaching of computer operations.

The methods described below, when supplemented by cooperative work programs and internships (see Section 5) support the curriculum's goal of producing graduates with the personal, social, and technical skills necessary to meet the challenges of industry.

Hands-on training. Extensive hands-on training with up-to-date equipment is necessary to meet the demands of industry, to satisfy student expectations, and to properly teach many skills. While some concepts can be learned through lectures, most skills must be learned through hands-on use of equipment. Extensive use of equipment also increases student motivation and fulfills the normal expectations of students entering computer operations programs. Although older equipment can be used to teach some skills, up-to-date equipment is required to learn most of the skills in this field since hardware changes so rapidly. Industry expects graduates of operations programs to be proficient in handling the latest equipment, as well as to understand basic concepts. Institutions must successfully meet these challenges to have an effective computer operations program.

Problem-solving approach. This report recommends and industry at large encourages use of a problem-solving approach for the teaching of computer operations. Teachers should propose, for solution by students, the kinds of everyday problems encountered in the field. They should also encourage innovative and creative thinking not only to solve immediate problems, but to improve the overall operation of the department. The idea of integrating knowledge and skills to achieve an optimal solution must be stressed. Students must also be made to understand that data processing is a team effort, in which students must pool their individual resources.

Hands-on laboratory simulation of a computer center. Hands-on laboratory simulation of a computer center can offer students a chance to encounter the types of problems that they will face on the job. Ideally such simulation will center around computer hardware currently used by industry.

The use of out of date computer equipment or the substitution of microcomputer can meet part, but only part, of the student's needs. Properly administered, computer center simulation motivates the student, provides hands-on training, and affords the opportunity to exercise problem solving skills. Moreover, it encourages development of personal/social skills and the ability to work in small teams. In a laboratory simulation, students should be challenged with problems that demonstrate their mastery of computer operations concepts and skills. Such simulation enhances operations training by offering the student industry-type situations to study and evaluate.

An effective computer center simulation requires full-time faculty, close contact with the school's computer center staff, up-to-date equipment, adequate funding, and the cooperation of local industry.

Computer-based training (CBT). Many computer-assisted instruction (CAI) packages have already been developed to teach computer operations. This report strongly supports CAI as a solution to many of the problems in teaching computer operations. By cheaply and conveniently simulating console operations on various types of equipment, CAI:

- Allows students to "access" different kinds of computer equipment.
- Provides students with extensive hands-on computer time.
- Obviates the need to purchase large-scale computer equipment.

Although CAI requires tremendous effort to implement, it can greatly reduce hardware costs for the curriculum. See Appendix A.2 for lists of currently existing CAI programs.

5. Resources for Curriculum Implementation

5.1 Faculty

For a computer operations program to be effective, the teachers must be effective. First, the teachers must be qualified to train the students for the jobs toward which they're headed. This requires direct operations experience. The Committee recommends that persons hired to teach computer operations have at least the following qualifications:

- Five years of computer operations work experience--preferably with one year in computer operations management

or

- Three years of computer operations work experience and a bachelor's degree

Second, teachers of computer operations must spend considerable time in addition to their usual day-to-day preparation for classes. The teaching of computer operations is so new that today's teachers have to contend with a virtual absence of textbooks, guidance materials, and curriculum models. This means that teachers must develop their own classroom materials and spend time helping to set up, develop, and update the curriculum as well. Furthermore, computer operations teachers, most of whom are hired directly from industry, frequently face the added burden of working toward an academic credential as they teach. Institutions should be made aware of these special problems.

Third, teachers must be responsive to the needs of their students and the demands of their position. They must direct students toward their respective goals, providing help outside the classroom, if necessary, and counseling them about career opportunities. Although career counseling and placement services are properly functions of the institution, the success of such services depends heavily on the support of individual teachers.

Finally, the computer operations teacher must keep abreast of changes in the field and make sure that the curriculum meets the needs of industry. Teachers must endeavor unceasingly to acquire new information, learn new skills, and bring new material into the classroom. They must keep abreast of changes in equipment, software, teaching and management techniques, and the job market. To help keep current, the computer operations teacher is advised to visit local industry, monitor the current literature, keep frequent and close contact with the institution's advisory committees, and attend professional meetings, workshops, and seminars.

Institutions should appreciate the need for and difficulty in keeping their computer operations teachers up to date. The following quotation taken from James L. Rogers' review of an early draft of this report summarizes the situation. "Ironically, one result of taking these suggestions seriously is to place an even greater responsibility upon an already under-compensated instructurate. Community and junior colleges already face the problem of finding and retaining competent instructors, especially in an environment where, in a short time after graduation, the student is earning a better salary than the instructor. To require that these instructors become knowledgeable in additional areas such as laws relating to privacy and security may not be very realistic." (14)

5.2 Equipment

For a student to become a competent computer operator, extensive hands-on training is required. The quality of such training depends heavily on the equipment available at the school. In fact, many companies justifiably rate operations programs by the type of equipment used in training. We recommend strongly that before an institution initiates a program in computer operations, it makes sure that the students will receive the hands-on training they need. If the necessary equipment cannot be provided, leaders of local industry might be persuaded to share their facilities, since it is in their own best interest to support the education of future employees.

Institutions should also make sure that the equipment meets the needs of local industry. They should also make sure that the equipment is up to date. Since computer technology changes so rapidly, equipment purchased today may be obsolete in a few years. Institutions must be prepared to change or update their equipment as necessary.

The implementation of a program in computer operations requires a strong financial commitment from the institution. Equipment must be purchased and money allocated for facilities, supplies, and classroom materials. A computer room appropriately designed is an important consideration. Another is classrooms, which should be located close to the computer lab to allow for demonstrations of topics discussed in class. The classroom and computer lab should be structured to allow the students to make best use of the facilities available.

Minimum hardware requirements. To adequately train computer operators, the school should provide the following equipment as a minimum:

- a CPU with multiprogramming capability
- a system console (keyboard and video display unit)
- other I/O devices as determined by local needs.

Minimum software requirements. To adequately train computer operators, the equipment should have at least the following software:

- operating system (OS)
- job control language (JCL)
- an assembler language
- at least two high level languages (such as COBOL)
- sort program
- data base management system and inquiry language
- teleprocessing

- applications software packages (such as accounting packages) to simulate a computer center.

Optional hardware. The ideal system configuration would include a CPU with sufficient memory to support multiprogramming and spooling, several consoles, and at least one printer. Also recommended for training are other hardware items used by local industry. Such hardware might include:

- telecommunications and networking equipment
- optical character readers
- laser printers
- plotters
- paper tape reader/punches
- high level graphics equipment
- process control devices
- microfilm (fiche) equipment
- varied offline support equipment (bursters, decollators, sorters, etc.)

5.3 Advisory Committees

An advisory committee is imperative in keeping a computer operations program up to date. The committee should be drawn from industry and should meet once or twice annually to review the program in light of the latest innovations. Consultation with the advisory committee should be held before changing the curriculum or investing in new equipment.

5.4 Instructional Aids

There are few textbooks on computer operations. (Two notable exceptions are listed in Appendix A.1). We hope this report will encourage publishers and authors to write more computer operations textbooks.

Addresses for obtaining manuals published by the equipment manufacturers are listed in Appendix A.3. Audio-visual and programmed instructional aids are listed in Appendix A.2. Periodicals recommended for the library are listed in Appendix A.5.

5.5 Internships and Cooperative Work (Coop) Programs

Internships and co-op programs are temporary work opportunities for students that benefit both students and employers. For the employer, internships provide temporary help during vacations or peak workloads and also provide the opportunity to evaluate new employees without being required to offer them a full-time permanent job. For the student, internships provide the opportunity to learn business norms such as proper dress, attendance, punctuality, working with other people, and accepting responsibility. Internships and co-op programs can also help the student decide whether to make a lasting commitment to computer operations.

Internships, which may be either in an in-house computer center or in industry, also provide a healthy, productive change of pace from the classroom. While working as interns, students can decide which kind of company they prefer to work for, improve their interviewing and operations skills, help finance their education, and at the same time gain experience on up-to-date equipment. An internship is an important addition to a student's resume and is an excellent source of professional references.

5.6 Career Guidance

Job information. Professional societies, such as the Data Processing Management Association (DPMA) and the Association of Computing Machinery (ACM), publish material for their student chapters that describes aspects of the various computer-related jobs. (See Appendix D.) Federal agencies such as the Navy, Army, and Air Force publish handbooks giving career information, qualifications and interests, working environments, opportunities, related civilian jobs, and career paths. A careers booklet was published by the American Federation of Information Processing Societies (AFIPS) in 1980 (see Appendix E.2).

School counselors are another source of career information. However, they are often unfamiliar with newly developing technical fields. It is therefore important to have orientation sessions to allow the counseling staff and the technical faculty to exchange information for a more uniform counseling program for students.

Statistical information on the current job market can be obtained from the Department of Labor's Occupational Outlook Handbook (10). Salary statistics are given annually in the periodicals Datamation and Infosystems (see Appendix A.5). Projection of future job needs in the various computer-related fields can also be found in the Inventory of Computers in Higher Education. (3)

Aptitude Tests. Aptitude tests are available from several manufacturers; one was designed specifically to test computer operators (see Appendix E.1).

Placement services. Companies seeking to hire graduates of computer programs consider placement largely a technical matter, choosing to contact the teachers directly rather than use the school's placement services. The computer operations teacher is therefore likely to be the best single source of job information for a student seeking local employment. Ideally, though, the teacher should share job information with the school (and vice versa). Joint efforts almost always prove more valuable in the long run.

6. Articulation

Implementing a curriculum is only the first step toward establishing a viable career program in computer operations. Articulation must be established with industry, the educational institution, and the profession.

Industry. The cooperation of local industry is essential in making sure a computer operations program remains current and responsive to the needs of the community. The institution shuld maintain an open dialog with leaders of local industry, encouraging them to participate as program advisors and guest lecturers, share their equipment, sponsor work-study programs, and, perhaps, donate equipment to the institution.

In-house. The institution's own computer center is an excellent resource for the computer operations program. Articulation should be established with the center to provide internships and work experiences for operations students. Programs like these benefit all participants--students earn money and college credit, the center's staff improve their communication and operations skills, the institution has a pool of eager, well-screened students from which to observe future employees first hand, and the operations teachers can call upon the center's staff to evaluate aspects of the program in light of the staff's experiences with the students.

The institution should extend its computer operations program to accommodate persons with operations experience who wish to enter the program. A system should be set up to allow these people to challenge certain courses. If the challenge is successful, credit should be received.

Accreditation Agencies. Guidelines for use by accreditation agencies could help to ensure that technically oriented career programs produce quality graduates. Their recommendations could influence course content and encourage currency and responsiveness to community needs.

Computer operations is a challenging and dynamic field, central to industry, government, and commerce, and crucial to the functioning of every computer center. It is costly to teach, but even more costly to teach badly. The guidelines we offer here are a first step in establishing a viable program in computer operations--but only a first step. These guidelines must be reviewed by people qualified to review them, adapted to the specific needs of the institution and its surrounding community, developed into a feasible program, put to use in the classroom, and updated as technology and needs change. Only then will be have accomplished what we set out to do.

References

1. Arnow, Barry I., "The Problem with EDP Co-op Programs," Journal of Cooperative Education, Vol. 14 (May, 1978), pp. 42-45.

2. Couger, J. Daniel and Robert A. Zawacki, "Something's Very Wrong with DP Operations Jobs," Datamation, Vol. 25, No. 1 (March, 1979), pp. 149-158.

3. Hamblen, John, and Carol Landis, Eds., The Fourth Annual Inventory of Computers in Higher Education," EDUCOM. Series in Computing and Telecommunications in Higher Education, Westview Press, 1980.

4. Hansen, William A., "The Operator's Changing Status," Datamation, Vol. 25, No. 1 (January, 1979), pp. 189-193.

5. Hansen's Weber Salary Survey on Data Processing Positions, 1080 Green Bay Road, Lake Bluff, IL 60044.

6. Kechula, Michael A., "Automated Mini-Courses: Timely Solution for Operator Training Problems," Data Management, Vol. 16, No. 4 (April, 1978) pp. 24-29.

7. Kechula, Michael A., "Going Mini: The Advantages of Short, In-House Training Courses," Data Management, Vol. 15, No. 6 (June, 1977) pp. 30-35.

8. Kechula, Michael A., "Operator Training--Another Method," Data Management, Vol. 14, No. 9 (September, 1976), pp. 18-23.

9. Maryland Business Data Processing Advisory Committee Report on Computer Operations, 1974.

10. Occupational Outlook Handbook, 1975-1976, 1979-1980, U.S. Department of Labor, Bureau of Statistics.

11. Plog, Claudia, "A Needs Analysis for DP Operations" (unpublished).

12. Plog, Claudia, "Curriculum Recommendations and Guidelines for the Career Program in Computer Operations" (unpublished).

13. Rogers, James L., "Guiding College Career Programs," Datamation, Vol. 26, No. 6, (June, 1980), pp. 265-268.

14. Carroll, Theresa and Patricia Hendershot, "People Shortage or People Productivity: A Workload Analysis," Proceedings of the Eighteenth Annual Computer Personnel Research Conference, ACM SIGCPR Publication Order No. 443810, pp. 371-392.

APPENDICES

The lists contained in the following appendices are not purported to be exhaustive. However, these lists should aid the computer operations curriculum coordinator or instructor in developing, implementing, or updating the computer operations curriculum.

APPENDIX A: REFERENCE MATERIALS

A.1 Textbooks

1. Fuori, William M., D' Arco, Anthony, and Orilla, Lawrence, Introduction to Computer Operations. McGraw-Hill Book Co. (1973).

2. Leeson, Marjorie, Computer Operations Procedures and Management, Science Research Associates, Inc. (1978).

A.2 Audio-Visual and Programmed Instruction Books

1. Available from Advanced Systems, Inc., 1601 Tonne Road, Elk Grove Village, IL 60007:

   - Computer Operator Training I/O Devices (1900)
   - Computer Operator Training 370 I/O Devices (1901)
   - POWER/VS System Operator Training (1931)
   - VS1 System Operator Training (1980)
   - VS2 System Operator Training (1982)
   - MVS System Operator Training (JES2)

2. Available from DELTAK, Inc., 1220 Kensington Road, Oak Brook, IL 60521:

   - Advanced MVS-JES2 for Operators
   - Advanced OS Operator Training - MFT
   - Advanced OS Operator Training - MVT
   - Advanced VS1 for Operators
   - DOS for Operators
   - DOS POWER for Operators
   - DOS/VS for Operators
   - HASP for Operators
   - MVS-JES2 for Operators
   - OS Operator Training - MFT
   - OS Operator Training - MVT
   - VS1 for Operators

3. Available from Honeywell Information Systems, Inc., 60 Walnut St., Wellesby Hills, MA 02181:

   - GCOS Operators Training, Peripheral Techniques (26090)
   - Series 200/2000 Operator Training (19040)
     - Text - Peripherals (HV004)
     - Text - Console and Control Panels (HV006)
   - OS/2000 Operations (19540)
     - Text (HV021)

4. Available from Edutronics Division of McGraw-Hill, 55 Corporate Division, 9300 West 110th St., 1221 Avenue of the Americas, New York, NY 10020:

   - MVS Operator Training
   - 360 Operator Training
   - 360 I/O Device Operations
   - 370 I/O Device Operations
   - MVS Operator Training

5. Self-study courses available from IBM, Customer Education, 1133 Westchester Ave., White Plains, NY 10604:

   - CMS for Operators (text)
   - OS/VS1 Basic Operations (audio)
   - OS/VS2 Release 1 Basic Operations (audio)
   - Operator Control of DOS/VS (video)
   - MVS Operator Training Topics (audio & text)
   - Operating the VM Console (text)
   - VM/370 CP Operations (text)
   - VM/370 CMS for Operators (text)
   - Operating OS/VS Under VS/370 (text)
   - Operating DOS/VS Under VS/370 (text)

6. "Audio/Visual Instruction for Data Processing", Computing Newsletter for Community Colleges, Vol. XII, No. 9 (May, 1979), J. Daniel Couger, editor, Box 7345, Colorado Springs, CO 80933.

7. IBM products available to automate computer operations mini courses:

   - Interactive Instructional System (IIS) mini-course combination accessed through the IBM 3277 Display Station via VM/370 CMS). For information order: Interactive Instructional System General Information Manual GH20-1895 from the nearest IBM office.
   - Interactive Training System (ITS), program product 5734-XXC. For information order Interactive Training System General Information Manual GH20-1170.
   - IBM also has a description of mini-course goals in the IBM Technical Report 02.750 October 23, 1976, and a publication, Computer Based Training Use Guide GE 20-0484.

A.3 Operations Manuals.

Each computer manufacturer produces a series of manuals for its own specific hardware configurations. These manuals are normally written for experienced computer operations personnel. Some manufacturers also produce instructional materials (see Appendix A.2). Some of the computer equipment manufacturers in the United States are:

1. Amdahl Corporation, 1250 E. Arques Avenue, Sunnyvale, CA 84086.
2. Burroughs Corporation, Burroughs Place, Detroit, MI 48232.
3. Control Data Corporation, P.O. Box 0, 8100 34th Avenue, Minneapolis, MN 55440.
4. Digital Equipment Corporation, 146 Main Street, Maynard, MA 01754.
5. Honeywell Incorporated, Honeywell Plaza, Minneapolis, MN 55408.
6. International Business Machines Incorporated, Old Orchard Road, Armonk, NY 10504.
7. Itel Corporation, One Embarcadero Center, San Francisco, CA 94111.
8. NCR Corporation, 1700 S. Patterson Blvd., Dayton, OH 45479.
9. Sperry Rand Corporation, 1290 Avenue of the Americas, New York, NY 10019.

A.4 Dictionaries and Glossaries

1. Computer Dictionary, Spencer, Donald D., Camelot Publishing Company, Inc., P.O. Box 1357, Ormond Beach, FL 32074 (1977).
2. SRA Data Processing Glossary, Science Research Associates, 1540 Page Mill Road, Palo Alto, CA 93404 (1979).

A.5 Periodicals

1. Byte, 70 Main St., Peterborough, NH 03458.
2. Computer Decisions (monthly), Hayden Publishing Company, P.O. Box 8309, Philadelphia, PA 19101 (free to some educators - use form in magazine).
3. Computers and People (monthly), 815 Washington Street, Newtonville, MA 02160.
4. Computerworld (weekly newspaper), 797 Washington Street, Newtonville, MA 02160.
5. Computing Newsletter (monthly), Box 7345, Colorado Springs, CO 80933.
6. Creative Computing, P.O. Box 789-M, Morristown, NJ 07960.
7. Data Management (monthly), Data Processing Management Association, 505 Busse Highway Park Ridge, IL 60068 (free to DPMA members).
8. Datamation (monthly), P.O. Box 2000, Greenwich, CT 06830 (free to educators with letter on company paper).
9. Dr. Dobbs (monthly), P.O. Box F, Menlo Park, CA 94025.
10. Government Data Systems (bimonthly), United Business Publications, 750 Third Avenue, New York, NY 10017.
11. Infosystems (monthly), Hitchcock Publishing Company, Hitchcock Buildings, P.O. Box 3007, Wheaton, IL 60187 (free to educators and other qualified personnel).
12. Interface Age, 16704 Marquardt Ave., Cerritos, CA 90701.

13. Interface: The Computer Education Quarterly (quarterly), 116 Royal Oaks, Santa Cruz, CA 95066.
14. Micro, P.O. Box 6502, Chelmsfort, MA 01824.
15. Microcomputing, P.O. Box 997, Farmingdale, NY 11737.
16. Micro Shopper, The Microcomputer Guide (quarterly), MicroAge Wholesale, 1425 W. 12th Place, Tempe, AZ.
17. On Computing, 70 Main St., Peterborough, NH 03458.
18. Personal Computing, 1050 Commonwealth Ave., Boston, MA 02215.
19. Recreational Computing, P.O. Box E, Menlo Park, CA 94075.
20. Small Business Magazine, 33 Watchung Plaza, Montclair, NJ 07042.

APPENDIX B: EXISTING COMPUTER OPERATIONS TEACHING PROGRAMS

The following list of institutions have operations programs and have indicated their willingness to share information on their programs. The list is not purported to be exhaustive. However, it should be of some assistance to those institutions attempting to develop and implement a computer operations program.

1. Angelina College, P.O. Box 1768, Lufkin, TX 75901.
2. Boulder Valley VOC-TECH, 6600 Arapahoe, Boulder, CO.
3. Central Piedmont Community College, P.O. Box 4009, Charlotte, NC 28204.
4. Central Texas College, CS Department, Box 46, West Highway 190, Kileen, TX 76541.
5. Charlottesville-Albemarle Tech., Educational Center, 1000 East Rio Road, Charlottesville, VA 22901.
6. Chattanooga State Technical Community College, 4501 Amnicola Highway, Chattanooga, TN 37406.
7. Cisco Jr. College, Rt. 3, Box 3A, Cisco, TX 76437.
8. Citrus College, 18824 E. Foothill Blvd., Azusa, CA 91702.
9. Clark Community College, 1800 E. Mcloughlin Blvd., Vancouver, WA 98663.
10. College Du Page, 22nd St. & Lambert Road, Alenellyn, IL 60137.
11. College of the Mainland, 9001 Palmer Hwy., Texas City, TX 77590.
12. Daytona Beach Community College, P.O. Box 1111, Daytona Beach, FL 32015.
13. Del Mar College, 101 Baldwin, Corpus Christi, TX 78404.
14. Des Moines Area Community College, 2006 Ankeny Blvd., Ankeny, IA 50021.
15. El Camino College, 16007 Crenshaw Boulevard, Torrance, CA 90506.
16. El Centro College, Main at Lamar, Dallas, TX.
17. Fullerton College, 321 East Chapman Avenue, Fullerton, CA 92634.
18. Gateway Technical Institute, 1001 South Main Street, Racine, WI 53403.
19. Hopewell High School, 400 South Mesa Drive, Hopewell, VA 23860.
20. J. Sargeant Reynolds Community College, VA.
21. Jefferson Sr. High School, 2305 Pierce Street, Edgewater, CO 80214.
22. Kilgore College, 1100 Broadway, Kilgore, TX 75662.
23. Kirkwood Community College, 6301 Kirkwood Blvd. S.W., P.O. Box 2068, Cedar Rapids, IA 52406.
24. Lane Community College, Eugene, OR 97405.
25. Madison Area VTAE District, 211 North Carroll Street, Madison, WI 53703.
26. Maricopa Technical Community College, 106 E. Washington Street, Phoenix, AZ 85004.
27. McLennan Community College, 1400 College Drive, Waco, TX 76708.
28. Milwaukee Area VTAE District, 1015 North Sixth Street, Milwaukee, WI 53203
29. Montgomery College, Rockville, MD 20850.
30. Moraine Park VTAE District, 235 North National Avenue, Fond du Lac, WI 54935.
31. National Business College, 8 Franklin Road, Roanoke, VA 24009.
32. National Technical Institute for the Deaf, Rochester Institute of Technology, One Lomb Memorial Drive, Rochester, NY 14623.
33. New River Community College, Drawer 1127, Dublin, VA 24084.
34. Odessa College, P.O. Box 3752, Odessa, TX 79760.

35. Paris Junior College, Paris, TX 75460.
36. Parkland College, 2400 West Bradley Avenue, Champaign, IL 61820.
37. Patrick Henry Community College, P.O. Drawer 5311, Martinsville, VA 24112.
38. Patrick Henry High School, 2101 Grandin Road, S.W., Roanoke, VA 24015.
39. Pearl River Junior College, Station A, Poplarville, MS 39470.
40. Portland Community College, 12000 S.W. 49th Avenue, Portland, OR 97219.
41. San Antonio College, 1300 San Pedro Avenue, San Andonio, TX 78284.
42. St. Clair County Community College, 323 Erie Street, Port Huron, MI 48060.
43. Seattle Central Community College, 1701 Broadway, Seattle, WA 98122.
44. Temple Jr. College, 2600 S. 1st Street, Temple, TX 76501.
45. Waukesha County Technical Institute, 800 Main Street, Pewaukee, WI 53072.
46. Western Wisconsin VTAE District, Sixth and Vine Streets, La Crosse, WI 54601.
47. Wharton County Junior College, 911 Boling Highway, Wharton, TX 77488.
48. Wisconsin Indianhead Technical Institute, 1900 College Drive, Rice Lake, WI 54868.
49. Wisconsin Indianhead Technical Institute, 600 North 21st Street, Superior, WI 54880.

APPENDIX C: VOCABULARY

abend
abort
access method
access time
accumulator
adaptor
address
ALGOL
algorithm
allocate
allocation
alphanumeric
ALU
analog computer
analyst
ANSI
APL
application
architecture
ASCII code
assemble
assembly
audit trail
automation
auxiliary storage

background
backup
BASIC
batch processing
baud
BCD
binary
bit
block
board
book
bootstrap
BPI
branch
buffer
bug
burster
bus
business
byte

CAI
cancel
card
card hopper
card reader
card stacker
carriage tape
cassette tape
catalog
chain printer
chaining
channel
character
check
checkpoint
checkpoint restart
check list
chip
circuit
COBOL
code
collate
collator
COM
command
communication network
compatible
compilation
compile
compiler
compute
computer
computer room
condition
configuration
console
constant
control total
control unit
controller
conversion
copy
core
core-image library
counter
CPU
CRT
cursor
customer engineer
cycle

cylinder

DASD
data
data base
data cell
data entry
data processing
data set
debug
deck
decode
decollator
delete
demand mode
density
device
device independent
diagnostic
digital computer
direct access
directory
disabled
disk
diskette
display
distributed data processing
DITTO
documentation
DOS
downtime
drive
drum
DSERV
dual density
dumb terminal
dump
duplex
duplicate
dynamic

EBCDIC
edit run
EDP
electrostatic printer
emulate
enable
encode
end-of-tape marker

end-of-transmission block character
end-of-transmission character
entry
EOF
EOJ
EOR
EOT marker
EPROM
erase
EROM
execute
executive
exit
EXTENT

fail-soft
fault book
field
fiche
FIFO
file
file maintenance
file protection ring
firmware
first in first out
fixed length record
fixed point
flowchart
floating point
floppy disk
form
form tractors
foreground processing
Format
FORTRAN
frame
frontend processor
function

"garbage in garbage out"
generator
generic
GIGO
graphics

half-word
hard copy
hardware

HASP
head
header label
hexadecimal
high-level language
hollerith code
hub

I/O
IBG
IBM
ID
identifier
impact printer
implementation
indirect
indexed sequential file
initialize
input
inquiry
installation
instruction
integrated circuit
intelligent terminal
interactive terminal
interblock gap
interface
interpreter
interrupt
IOCS
IPL
IRG
ISAM

JCL
JECL
JES
job
job control card
job setup sheets
job step
job stream

K
KB
key
keypunch

label
left justify

leader
library
LIFO
line printer
link
linkage editor
list
listing
load
load-point marker
location
log off
log on
logical record
logical translator
logical unit
lookup
loop
lpm

machine language
macro
magnetic core
magnetic disk
magnetic drum
magnetic tape
main frame
main storage
maintenance (hardware)
mask
mass storage device system (MSDS)
master file
match
media
megabyte
memory
merge
MFT
MICR
microcomputer
microfiche
microfilm
microsecond
millisecond
minicomputer
MIS
mode
modem
module
modular

modulator
monitor
motherboard
MPU
multiplexor channel
multiprocessing
multiprogramming
MVT

nanosecond
network
nonimpact printer
non-process run out
NPRO
NRZI
numeric
object program
OCR
octal
OEM
offline
online
operator
operand
operating system
operation code
opscan
optical scanner
original equipment manufacturer
OS
output
overflow
overflow area
overlay

pack
page
page frame
page in
page out
parallel processing
parity bit
parity check
partition
parts
P ASCAL
password
PCM
performance
peripheral equipment

physical record
PL/I
plotter
plug compatible
PM
polling
port
POWER
preprinted forms
preventative maintenance
printer
priority
private library
procedure library
process
processor
program
program status word
programmer
protection
pushbutton

query
queue

RAM
random access
read check
read/write head
real storage
real time
record
recovery
reel
register
relational
relocatable library
remote access
report
report program generator
reproduce
reproducer
resources
response time
restart
retrieval
right justify
RJE
ROM
RPG

run book
runaway forms

sabotage
scanner
schedule
scratch tape
secondary
security
seek
selector channel
sequence check
sequential
sequential file update
setup
setup deck
simulation
simulator
smart terminal
software
sort
sorter
source document
source language
source statement
source statement library
special character
special forms
spool
spooling
sporting
storage
stream
structured
switch
SYSRES
system flowchart
system generation (SYSGEN)
systems department
supervisor

tape
tape label
tape mark
tape unit
task
telecommunications
terminal
text
thermal printer

thrashing
throughput
timesharing
trace
track
trailer label
transaction file
transfer
transient area
transistor
turnaround
turnaround time

unbundled
unit
unit record
unit record equipment
update
uptime
user
utility program

vacuum column
validity check
variable length record
vender
verify
virtual machine
virtual storage
VM
volume
volume table of contents
VS
VSAM
VTOC

winchester disk
word

x-punch

y-punch

zero suppress
zone punch

APPENDIX D: STUDENT MEMBERSHIPS

1. Data Processing Management Association (DPMA). A student DPMA chapter is suitable for computer operations students. For information, contact your local DPMA chapter or write the Student Chapter Coordinator at: DPMA, 505 Busse Highway, Park Ridge, IL 60068.
2. Association for Systems Management (ASM).
3. Association for Computing Machinery (ACM), 1133 Avenue of Americas, New York, NY 10036.

APPENDIX E: APTITUDE TESTS AND CAREER REFERENCES

E.1 Aptitude Tests

1. COAB - Computer Operator Aptitude Battery, Science Research Associates, Inc., 259 E. Erie St., Chicago, IL 60611.
2. Automated D.P. Equipment Operators Exam, Form # 0175-0221, 23, 25, Merit System Council of the State of Texas, 407 Brown Bldg., P.O. Box 1389, Austin, TX 78767.
3. Wonderlic Personnel Test, E. F. Wonderlic and Association Inc., P.O. Box 7, Northfield, IL.

E.2 Career References

1. "A Look into Computer Careers," American Federation of Information Processing Societies Inc., 1815 N. Lynn Street, Arlington, VA. 22209, 1980.
2. "Your Career in Data Processing," Data Processing Management Association, 505 Busse Highway, Park Ridge, IL 60068.
3. Maniotes, John and Quasney, James S., *Computer Careers*, Hayden Publishing Co., 1974.
4. McDaniel, Herman, *Careers in Computers and Data Processing*, Petrocelli Books, 1978.
5. *Army Occupational Handbook*. Contact your local U.S. Army Recruitment Office.
6. *Navy Occupational Handbook*. Contact your local U.S. Navy Recruitment Office.
7. *Guidance Information Data Bank* (GIS), Time Share Corp., P.O. Box 683, Hanover, NH 03755. This package gives the following information:
    - skills necessary in a career
    - aptitudes necessary
    - interests involved
    - educational level needed
    - salary information
    - employment potential by state

APPENDIX F: DEFINITIONS OF COMPUTER OPERATIONS POSITIONS

The following job descriptions closely parallel those in "Hansen's Weber Salary Survey on Data Processing Positions."

1. Computer operations manager. Directs the computer operations section in the operation of the mainframe and peripheral data processing equipment. Usually considered to be in full charge of all activities relating to computer operations. Establishes detailed schedules for the utilization of all equipment in the computer operations section to obtain maximum usage. Assigns personnel to the various operations and directs their activities. Reviews and evaluates the work of own staff and prepares periodic performance reports. Consults with personnel in other data processing sections to coordinate activities. Reviews equipment logs. Prepares computer operations section. Normally reports to the corporate or divisional manager of data processing or the data processing operations manager.

2. Computer operator

a. Computer operator - lead. Under general direction, has full technical knowledge of computer operations as does a senior computer operator, but also has supevisory duties of instructing, assigning, directing, and checking the work of the other computer operators. Assists in the scheduling of the operations. Coordinates activities of the section with other sections. May act as shift supervisor. May act as manager in his or her absence.

b. Computer operator - senior. Under general direction, monitors and controls a computer by operating the central console. Usually competent to work at the highest level of all computer operations phases while working on own most of the time. May give some direction and guidance to other computer operators. Studies program operating instruction sheets to determine equipment setup and run operations. Manipulates control switches on console to start and operate the computer. Observes continuously the operation of the console panel, storage devices, printers, readers, punches and the action of the console typewriter to monitor the system and determine the point of equipment or program failure. Manipulates controls in accordance with standard procedures to rearrange sequence of program steps in order to correct computational errors or to continue operations when individual units of the system malfunction. Confers with technical personnel in the event of errors requiring a change of instructions or sequence of operations. Maintains operating records such as machine performance and production reports.

c. Computer operator - A. Under general supervision, monitors and controls a computer in accordance with established routines. Usually competent in most phases of computer operations to work on own, requiring some general direction for the balance of the activities. Assists in determining equipment settings and operating instructions. Manipulates control switches on console panel in accordance with established routine or under instructions. Observes continuously the operation of the equipment, reporting any deviations from standard. May assist in manipulating controls to rearrange sequence of program steps to correct computational errors or to continue operations when individual units of the system malfunction. Assists in maintaining operating records.

d. Computer operator - B. Under direct supervision, assists in monitoring and controlling a computer. Usually competent to work on several phases of computer operations with only general direction, but still needs some instruction and guidance for the other phases. Manipulates control switches on console panels, storage devices, printers, readers, and punches in accordance with detailed instructions. Assists in carrying out the various duties associated with operating a computer in connection with the computer itself or the auxiliary equipment directly associated with the computer. May keep records regarding output units and maintain records for stores and supplies.

e. Computer operator - C. Under immediate supervision, assists in performing relatively routine duties in accordance with detailed instructions. This level is usually staffed by beginners who have had sufficient educational background and/or experience to qualify them to start in computer operations.

f. Media librarian. Maintains a library of paper tapes, cassettes, magnetic tapes, disks, and diskettes used for data processing efforts. Classifies and catalogs tapes and disks by content, type of routing, retention, and informational importance. Assigns codes conforming with standard systems. Issues reels/disks to computer operations according to classification and catalog designation. Maintains charge-out records. Maintains security of tapes and disks and their informational content. Inspects returned reels to determine if tape needs replacing due to wear or damage.

g. Scheduler. Under general direction, schedules operating time of data processing operations to ensure that the data procesing equipment is effectively utilized. Responsible for keeping unutilized time to a minimum by maintaining liaison with section managers and reasigning unused time. Coordinates preventive maintenance requirements with operating requirements.

5. Data Control Positions

a. Data control supervisor. Directs the activities of the data control section. Usually considered as being in full charge of all data control activities. Assigns work to personnel and directs their activities. Reviews and evaluates work of own staff and prepares periodic performance reports. Normally reports to data processing operations manager.

b. Data control clerk - lead. Under general direction, assists in supervising the activities of a group engaged in maintaining and revising lists, control records, and source data used in the preparation of recurring records and reports. Assigns work to other clerks and assists in their training.

c. Data control clerk - senior. Under general supervision, maintains the various control records and source data used in the preparation of recurring reports; may code source data and lists according to prescribed code designations; performs related clerical and typing duties. May instruct other clerks on procedures used to perform routine assignments; may assist in training new employees.

d. Data control clerk. Under direct supervision, maintains the control records and coding schemes necessary to process source data, codes data and calculates batch totals where appropriate, inputs data with necessary documentation for computer processing, audits output to ensure that control totals are correct, and distributes output reports per predetermined instructions. Performs related clerical duties.

e. Data control clerk - trainee. Under immediate supervision, is in training capacity to determine suitability for data control work.

6. Peripheral equipment operator. Assists the operator in monitoring and controlling the computer. Performs routine tasks with computer room equipment and support equipment to supplement the computer operators efforts. May perform some record-keeping tasks and supply functions.

7. Other operators. Other positions in computer operations may include: shift supervisors, data entry personnel, forms control specialists, production control specialists, and documentation specialists.

APPENDIX G: CONTRIBUTORS AND WORKSHOP PARTICIPANTS

1. ACM C^3E-CAJC Workshop at Gloucester Point, VA, August 25-26, 1977:

   - Austing, Richard, H., University of Maryland, College Park, MD
   - Ciero Richard, Thomas Nelson Community College, Hampton, VA
   - Dineen, John (Jack), Middlesex County College, Edison, NJ
   - Engel, Gerald L., Old Dominion University, Norfolk, VA
   - Hutcheson, Donna, East Texas State University, Commerce, TX
   - Lee, Iva Helen, McLennan Community College, Waco, TX
   - Leeson, Marjorie, Delta College, University Center, MI
   - Little, Joyce Currie, Community College of Baltimore, Baltimore, MD
   - Lloyd, John (Jack), Montgomery College, Rockville, MD
   - Plog, Claudia E. (Bette), El Centro College, Dallas County Community District, TX
   - Ramach, Joseph, State of Maryland, Baltimore, MD
   - Seeds, Harice, Los Angeles City College, Los Angeles, CA
   - Stonebeck, John P., Northhampton County College, Bethlehem, PA
   - Sweeney, John, National Technical Institute for the Deaf, Rochester, NY
   - Vernon, Erwin, Sinclair Community College, Dayton, OH
   - Westley, John W., Illinois Central College, East Peoria, IL
   - Wood, Jacqueline A., University of Alabama, Birmingham, AL
   - Woodcock, Raymond W., Boulder Valley VOC-TECH Center, Boulder, CO

2. ACM C^3E-CAJC Workshop, Detroit, MI, February 22, 1978:

   - Austing, Richard H., University of Maryland, College Park, MD
   - Ciero, Richard, Thomas Nelson Community College, Hampton, VA
   - Engel, Gerald L., Old Dominion University, Norfolk, VA
   - Hutcheson, Donna, East Texas State University, Commerce, TX
   - Lee, Iva Helen, McLennan Community College, Waco, TX
   - Leeson, Marjorie, Delta College, University Center, MI
   - Little, Joyce Currie, Community College of Baltimore, Baltimore, MD
   - Lloyd, John (Jack), Montgomery College, Rockville, MD
   - Schrage, John, Indiana University-Purdue University, Ft. Wayne, IN
   - Seeds, Harice, Los Angeles City College, Los Angeles, CA
   - Sweeney, John, National Technical Institute for the Deaf, Rochester, NY
   - Vernon, Erwin, Sinclair Community College, Dayton, OH
   - Woodcock, Raymond, Boulder Valley VOC-TECH, Boulder, CO

3. ACM C^3E-CAJC Workshop, Pittsburgh, PA, August 15-17, 1978:

   - Little, Joyce Currie, Community College of Baltimore, Baltimore, MD
   - Pollack, Morris, Bronx Community College, Bronx, NY
   - Seeds, Harice, Los Angeles City College, Los Angeles, CA
   - Stonebeck, John P., Northampton County College, Bethlehem, PA
   - Sweeney, John, National Technical Institute for the Deaf, Rochester, NY

- Travis, Stuart, Ferris State University, Big Rapids, MI
- Vernon, Erwin, Sinclair Community College, Dayton, OH
- Walton Richard, National Technical Institute for the Deaf, Rochester, NY
- Woodcock, Raymond W., Boulder Valley VOC-TECH Center, Boulder, CO

4. ACM C^3E-CAJC Workshop, Dayton, OH, February 21-22, 1979:

    - Schrage, John, Southern Illinois University at Edwardsville, Edwardsville, IL
    - Seeds, Harice, Los Angeles City College, Los Angeles, CA
    - Sweeney, John, National Technical Institute for the Deaf, Rochester, NY
    - Vernon, Erwin, Sinclair Community College, Dayton, OH
    - Wood, Jacqueline A., University of Alabama, Birmingham, AL
    - Woodcock, Raymond W., Boulder Valley VOC-TECH, Boulder, CO
    - Walton, Richard National Technical Institute for the Deaf, Rochester, NY
    - Westley, John W., Illinois Central College, East Peoria, IL

5. ACM C^3E-CAJC Workshop, Arlington, TX, August 20-22, 1979:

    - Kechula, Mike, IBM, Dallas, TX
    - Lee, Iva Helen, McLennan Community College, Waco, TX
    - Little, Joyce Currie, Community College of Baltimore, Baltimore, MD
    - Plog, Claudia E. (Bette), El Centro College, Dallas County Community District, TX
    - Sanders, Ray, North Texas State University, Denton, TX
    - Seeds, Harice, Los Angeles City College, Los Angeles, CA
    - Sweeney, John, National Technical Institute for the Deaf, Rochester, NY
    - Walton, Richard, National Technical Institute for the Deaf, Rochester, NY
    - Woodcock, Raymond W., Boulder Valley VOC-TECH Center, Boulder, CO
    - Vernon, Erwin, Sinclair Community College, Dayton, OH
    - Gordier, Gerald, City of Midland, Midland, MI

6. Additional contributors:
    - Allen, Charles A., Virginia Community College System, Richmond, VA
    - Bachmann, Glenn, Eastman Kodak, Rochester, NY
    - Berl, Bob, National Technical Institute for the Deaf, Rochester, NY Beckett, - Barbarann, Jefferson State Junior College, Birmingham, Alabama
    - Bolan, Bob, Eastman Kodak, Rochester, NY
    - Chadwick, Augusta, Los Angeles Trade-Technical College, Los Angeles, CA
    - Clark, Frank, Rochester Institute of Technology, Rochester, NY
    - Creasy, Gordon, State Dept. of Education, Richmond, VA
    - DiBattista, Ron, The University of North Carolina, Greensboro, NC
    - Fletcher, Dennis A., Informatics Incorporated, Canoga Park, CA

- Hansen, Bill, DELTAK, Oak Brook, IL
- Heinze, Kenneth J., All-Steel, Aurora, IL
- Jarvis, Everett, Community College of Baltimore, Baltimore, MD
- Jenkins, Robert, Utah Technical College at Provo, Provo, UT
- Kind, Harold, Waukesha County Technical Institute, Pewaukee, WI
- Majors, Faye, Emily Griffith Opportunity School, Denver, CO
- McKenzie, Wiley, Rochester Institute of Technology, Rochester, NY
- Michaelson, Mike, Palomar College, San Marcos, CA
- Oldfield, Bill, Eastman Kodak, Rochester, NY
- Reynolds, Mark, National Technical Institute for the Deaf, Rochester, NY
- Rhodes, Bo, Virginia Western Community College, Roanoke, VA
- Rogers, James L., Case Western Reserve University, Cleveland, OH
- Stabley, Donald, Eastman Kodak, Rochester, NY

7. Supporting personnel:
   - Beiderbecke, Laura, National Technical Institute for the Deaf, Rochester, NY
   - Bernard, Rosalie, National Technical Institute for the Deaf, Rochester, NY
   - Burnett, Joseph, National Technical Institute for the Deaf, Rochester, NY
   - Cerniglia, Dorothy, National Technical Institute for the Deaf, Rochester, NY
   - Chudoba, Petr, National Technical Institute for the Deaf, Rochester, NY
   - Fox, Dorris, National Technical Institute for the Deaf, Rochester, NY
   - Ingraham, Mary Jo, National Technical Institute for the Deaf, Rochester, NY
   - Kester, Cindy, National Technical Institute for the Deaf, Rochester, NY
   - Kulesa, Irene, National Technical Institute for the Deaf, Rochester, NY
   - McPhetres, Jane, National Technical Institute for the Deaf, Rochester, NY
   - O'Brien, Lorna A., National Technical Institute for the Deaf, Rochester, NY
   - Poquette, Katrina A., National Technical Institute for the Deaf, Rochester, NY
   - Shaffer, Betty, National Technical Institute for the Deaf, Rochester, NY
   - Tyler, Stella, Community College of Baltimore, Baltimore, MD

APPENDIX H. ACM COMMITTEE ON CURRICULUM FOR COMMUNITY AND JUNIOR COLLEGE EDUCATION, 1981

Chair:	Joyce Currie Little, Community College of Baltimore, Maryland
Members:	John (Jack) Dineen, Middlesex County College, Edison, New Jersey Dennis Fletcher, Informatics, Inc., Canoga Park, California Iva Helen Lee, McLennon Community College, Waco, Texas Marjorie Leeson, Delta College, University Center, Michigan John F. Schrage, So. Ill. Univ. at Edwardsville, Illinois Harice Seeds, Los Angeles County College, California John Sweeney, National Technical Institute for the Deaf, Rochester, New York Erwin Vernon, Sinclair Community College, Dayton, Ohio Ray Woodcock, Boulder Valley Voc-Tech Center, Boulder, Colorado

A MODEL CURRICULUM FOR DOCTORAL-LEVEL PROGRAMS IN HEALTH COMPUTING

Report of the ACM Committee on Curriculum for Health Computing Education

K.A. Duncan, R.H. Austing, S. Katz, R.E. Pengov,
R.E. Pogue, A.I. Wasserman

TABLE OF CONTENTS

vii Preface
ix Acknowledgment
1 1. Introduction
1 1.1 Rationale
3 1.2 Project Background
3 1.3 Path of Development and Curriculum Terminology
5 1.4 The Next Steps
6 2. The Core Curriculum
6 2.1 Core Curriculum Concepts
9 2.2 Core Curriculum Courses
12 3. Specialization Tracks
12 3.1 Track Concepts
13 3.2 Presentation of the Tracks
14 3.3 Health Information Systems
14 3.3.1 The Health Information Systems Specialist
14 3.3.2 Careers
15 3.3.3 The Health Information Systems Model Curriculum
24 3.3.4 An Example Implementation
25 3.4 Health Research Computing
25 3.4.1 The Health Research Computing Specialist
26 3.4.2 The Health Research Computing Model Curriculum
32 3.4.3 An Example Implementation
33 3.5 Education and Health Computing
33 3.5.1 The Health Educational Computing Specialist
33 3.5.2 Careers
34 3.5.3 The Health Educational Computing Model Curriculum
41 3.5.4 An Example Implementation
43 3.6 Health Computing Administration
43 3.6.1 The Health Computing Administration Specialist
44 3.6.2 Careers
44 3.6.3 The Health Computing Administration Model Curriculum
51 3.6.4 An Example Implementation
52 4. Implementation Issues
52 4.1 General Considerations
53 4.2 Specific Recommendations
56 5. The Shape of the Future
59 References
61 Biographies
63 Appendix A -- Core Curriculum Topics
67 Appendix B -- Core Curriculum Courses: Approach and Content

PREFACE

This set of curriculum recommendations for doctoral-level programs in health computing was developed by the Association for Computing Machinery Committee on Curriculum for Health Computing Education. It is the product of three years' work by a diverse and broadly representative group of experienced health computing professionals who are concerned about academic preparation for health computing careers. These formal guidelines are the first ever formulated and published for health computing education. They are intended for general use by educational institutions, faculty, students, planners, and funding bodies. The authors also intend the guidelines to serve as the basis for a better definition of the profession of health computing to promote the professionalism, the unified peer structure, and the recognized career paths that are characteristic of a stable and worthwhile profession.

ACKNOWLEDGMENT

The Writing Group is most grateful to the Committee members and friends whose enthusiasm, knowledge, experiences, and insights have been invaluable in the development of this document. These wonderful people are Marion Ball, Judith Bayard, Shanon Brunjes, Diane Katz, George Malindzak, David Mishelevich, Howard Moraff, Aran Safir, Roger Shannon, Fred Sias, Robert Tannenbaum, and Howard Thompson. Several individuals associated with the NLM-funded training programs in health sciences and computer technology also made substantial contributions to our work.

We also want to thank the ACM Committee on Curriculum for Computer Education and the ACM Education Board for their financial and moral support over the years we have struggled to formulate on paper our concepts of training in health computing. We are especially grateful to Bill Atchison, who was Chairman of the ACM Education Board for most of those years, and Jerry Engel, who chaired the ACM Education Committee during much of our work.

Finally, preparation of the final document would not have been possible without the help of our many reviewers from diverse areas of health care, computing, and health computing. Special thanks are due also to Rose Ann Merrey for processing the many drafts and to Sara Leigh Merrey, whose excellent editorial skills have enriched this document.

1 INTRODUCTION

1.1 RATIONALE

This report presents a model curriculum that is intended to serve as a guideline for the development of doctoral-level programs in health computing. The curriculum has its roots in the recognition that computer technology has been underutilized in health care research, delivery, education, and policy formation. This underutilization is particularly dramatic when compared with the potential benefit to the nation's health that an appropriate quantity and quality of utilization could provide.

The reasons for this range from the subtle -- such as the difficulty in introducing external elements into the health care delivery system -- to the not so subtle -- such as the tremendous costs that would be incurred in utilizing computer technology fully. For many of the factors hampering full utilization of computer technology, a significant underlying problem has been the shortage of qualified leadership in the field. Because of complexities peculiar to the health care delivery system, it has been a less than straightforward matter for the traditional computer scientist to adapt to that environment. Indeed, many attribute our failure to sustain the momentum of health care applications development of 20 or so years ago to the crisis of communication between computer scientists and health professionals. In recent years this professional communication crisis has been compounded by dwindling funds for support of the very expensive and time-intensive development of health applications and basic health computing research. The tasks of education and persuasion necessary for overcoming these critical bottlenecks point very strongly to an urgent need for leaders and practitioners in health computing, if computer technology is indeed to attain its proper role in helping to alleviate the health care crises extant in the world today.

Futurists knowledgeable about the health care system and information technology believe that computers provide us with the capability to radically alter our concepts of health and health care delivery. This undoubtedly would lead to a transformation in medical education and practice. To illustrate, consider the many knowledge-based information systems under development or in use in this country today. Clinical research in several medical disciplines has been markedly advanced through the use of these tools. But the current lag time between the research findings and their use in the classroom or the routine office practice is on the order of three to five years. How can we tap these databases for medical education and practice? Application of human-machine interface research and perhaps not yet invented software tools, combined with advances in communications technology and cheaper, more versatile hardware, could bring these databases into the office, hospital, or classroom in a meaningful, timely, and practical way. The men and women of vision who might achieve this synthesis are all too few.

As another example, consider the possibility of a complex health information system that aggregates information from hospitals, clinics, and demographic databases for planning and policy formation by public and private groups at the regional or national levels. Although the necessary software development is almost beyond comprehension, it pales beside the organizational, sociological, political, and even legal issues associated with such a development. Thousands of talented health computing professionals would be needed to design, develop, manage, and maintain such a system at all levels. These individuals would need a broad background in the health sciences, computer technology, the sociology of complex organizations, and the skills to integrate these disciplines and apply them through effective leadership.

The need for leadership in health computing is one of several rationales for the development of a model doctoral-level curriculum specifically for health applications. Another practical reason lies in the fact that at present credentials for leadership in the health field are attained only by about eight years of study after the bachelor's degree and upon successful achievement of certification by several different boards at the national level. The psychological, if not intellectual, stance that such training produces is in essence the "user" with which the computer science community must work -- the M.D. The authors of this report submit that a meaningful intellectual achievement in the field of medicine can only be attained by individuals who have comparable preparation to work in that milieu.

Another rationale for doctoral-level model curriculum development comes from the perceived absence of any other mechanism or effort within this country to begin to formalize health computing as a field to which professionals might be attracted, and within which they can find rewarding careers. Such efforts would in any case be hampered by an ill-defined job market, no career paths, no apparent unifying peer structure, lack of a respected niche in the health care delivery system, and lack of credentialing that would allow entry to the ranks of health professionals. Thus the model curriculum development effort in and of itself serves as an attempt to define the emerging profession of health computing.

It is evident that leaders in health computing must have not only more than a passing understanding of health science, computer science, and sociology but also the ability to integrate these traditional disciplines in a creative and effective manner. These requirements alone would argue for the lengthy training period typical of a doctoral-level program. Although there is a real need for ancillary professionals as well (1), this curriculum concerns itself with training for the leaders in the profession -- again, training at the doctoral level. Further, because of the elements of human service embodied in the concept of health computing, the Committee tends to view health computing in general as an emerging profession, rather than as a new discipline. That profession is grounded in the disciplines of computer science, health sciences, and sociology, especially of complex organizations. A further exposition of this rationale is given by Shannon and Duncan (2).

Despite the fact that the established professions do not generally require a research thesis, it is our belief that this profession is so far from reaching its full potential that all practitioners at this level should be experienced in the arts of inquiry and creativity and have the capability to write for publication. Graduates would be expected to initiate and otherwise contribute to applied research in the profession throughout their careers.

This introduction has addressed the rationale for and the philosophical underpinnings of the model curriculum; subsequent sections describe our development approach, the curriculum content, and some practical questions of implementation and the profession's future.

1.2 PROJECT BACKGROUND

The model curriculum development began in 1977 with the formation of the Committee for Curriculum in Health Computing Education (CHCE) under the ACM Education Board. In order for the Committee's ultimate recommendations to represent substantially all of the health computing community, its members were selected from the broadest possible range of viewpoints and experience. A number of professional societies were asked to name representatives to the Committee as well. Virtually all of the Committee members have doctoral degrees and many years of experience in health computing, so a leadership perspective was maintained.

In a parallel effort the ACM Special Interest Group for Computers in Biology and Medicine (SIGBIO) held a national Symposium on Careers in Health Computing to explore the variety of such careers and to learn firsthand from experienced health computing professionals just what training they believed would be most appropriate for the kind of work they do. Several CHCE members participated in the Symposium, and drafts of the Proceedings have been most valuable in stretching the perspective of our work (3).

A third source of experienced and valuable input early in our deliberations came from a joint meeting of the CHCE Committee and the Directors of the National Library of Medicine Training Program in Health Sciences and Computer Technology. This Federal program provides funds to about a dozen schools for graduate-level education "to promote the complete and effective integration of computer technology into all phases of clinical medicine" (4). A list of these and similar programs was recently published by SIGBIO (5).

1.3 PATH OF DEVELOPMENT AND CURRICULUM TERMINOLOGY

As the Committee first began compiling the competencies that graduates of an educational program in health computing should possess in order to embark on productive and rewarding careers, it quickly became evident that we were describing not one, but several different programs and careers. Accordingly, early in our curriculum development, we adopted the notion of a variety of specialty tracks that would provide different options for education based on a student's career goals.

Careers were grouped under tracks roughly based on commonalities of probable training requirements for convenience of description. For example, management intensive careers were grouped together (Health Computing Administration Track), as were those requiring extensive quantitative or engineering skills (Health Research Computing Track), those requiring more intensive computer science knowledge (Health Information Systems and Clinical Decision Making), and those most directly related to education (Health Educational Computing). These track concepts are listed in Table 1-1 for easy reference, and they are described more fully in Section 3.

Track	Career Type
Health Computing Administration	policy and management intensive
Health Information Systems	computer science intensive
Health Educational Computing	requiring educational skills
Health Research Computing	health science research that requires computation and engineering skills

Table 1-1. Specialty Track Careers

We next identified the knowledge basis, or types of knowledge or training, for each track that would provide the student with the necessary competency. But this diversity did not serve our intent that the curriculum be a unified document that helps to define the profession of health computing. We needed to discover the set of core knowledge requirements that would characterize all members of our profession, whether teachers, researchers, practitioners, or managers (analogous to the knowledge required for the national board examinations characteristic of such other professions as medicine or law). So we abstracted the common knowledge -- that which would be required by every track for every career -- to serve as the core knowledge of a health computing specialist. These core requirements were described in detail in an earlier publication (6); the list of topics to be mastered is given in Appendix A.

Statement of core knowledge is a discipline-defining exercise in and of itself; however, we wanted to make the material more practical and better convey our sense of how the material should be integrated to assist the student in achieving basic competency. Accordingly, the authors apportioned the core knowledge among 14 core courses. These courses and their interrelationships are described fully in Section 2.

There remained, finally, to show the nature of the remaining specialty track requirements and how these elements blend with the core requirements to constitute the full doctoral-level curriculum. All four sets of track requirements and a sample curriculum implementation plan for each track are discussed in Section 3.

We believe this stepwise approach to curriculum development has led to the most objective view possible for establishing training requirements. An approach that begins with career definition and the necessary competencies provides goals against which training requirements can be judged. The competency-based development steps we used are summarized in Table 1-2.

Task
Identify careers
Establish end-point competencies for the careers
Group careers with similar competencies into specialty tracks
Establish requirements to achieve competencies
Identify topics to be taught as part of training
Identify core, or common, topics
Arrange topics into sets of courses
Develop curriculum examples

Table 1-2. Competency-Based Approach
to Curriculum Development

1.4 THE NEXT STEPS

The authors are aware that this model curriculum is extensive and complex. Many of the courses are new, and the problems of implementation are significant. Nonetheless we believe this document serves as a sturdy model, or point of reference, for implementation in a variety of settings. Our viewpoint and suggestions for coping with some of these potential problem areas are discussed in Section 4.

Since health computing as a profession is just beginning to define its foundations, this document can only be considered as a starting point that attempts to synthesize and extend much of the current view of the profession. Our labors over the last several years will be rewarded by the extent to which we succeed in stimulating interest and thoughtful consideration of all aspects of health computing careers. Our own plans for future efforts in this regard are discussed in Section 5.

2 THE CORE CURRICULUM

2.1 CORE CURRICULUM CONCEPTS

The core curriculum consists of a set of courses that provides the core knowledge required for all health computing specialists. The set of courses developed by the authors represents one practical mapping of the core knowledge given in Appendix A into a practical program of study. Other mappings are possible, however, to take advantage of courses already available at a particular institution.

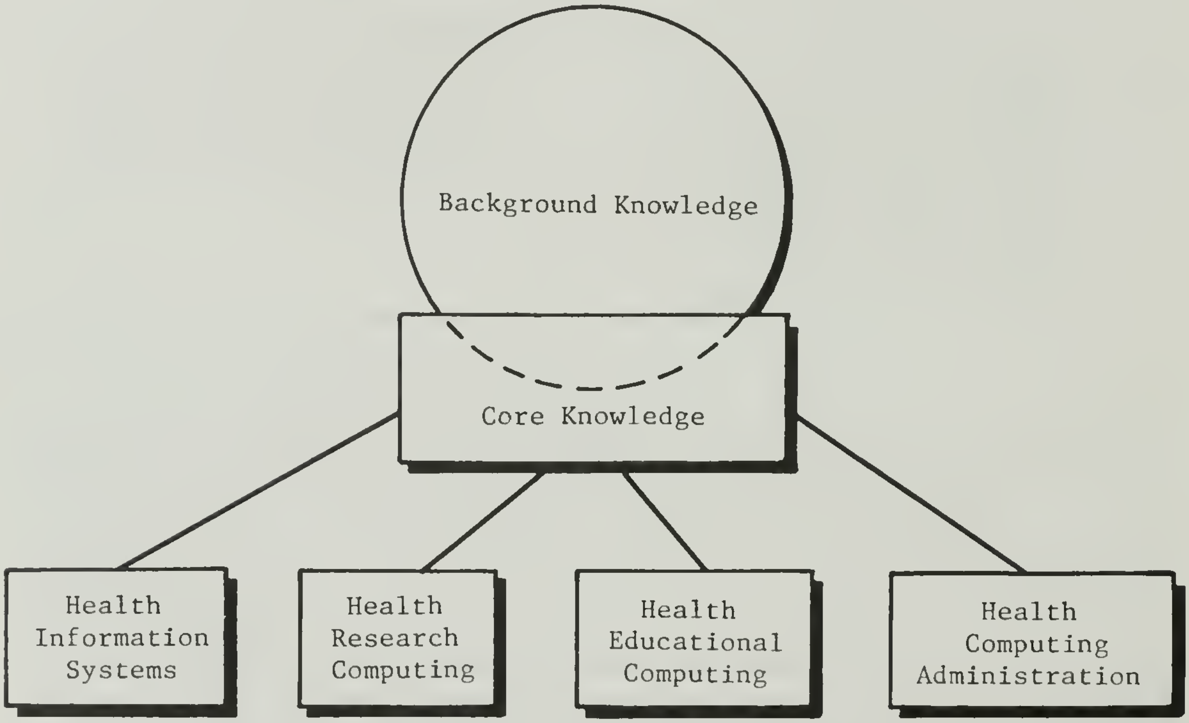

Background Knowledge
Core Knowledge
Health Information Systems
Health Research Computing
Health Educational Computing
Health Computing Administration

Figure 2-1. Relationship of Elements of the Model Curriculum

In developing the core curriculum, the critical parameter to consider is the student's end-point competency. Thus the goal here is not to specify an ideal entering student, but to achieve a competent graduate. To create the necessary competency, the core requirements are broad; no specific background is required to enter a program beyond a demonstrated aptitude for computing concepts (as evidenced by an understanding of Assembler language concepts and one or two years' experience with a high-level programming language). Additional prerequisites may be required, however, by the various specialty tracks, and calculus and biology are strongly recommended. Our experience also leads us to believe that mature students who are highly motivated are needed. In these early years of the profession, such students might come from a variety of computing or health care backgrounds. Thus their preparation may overlap some of the core content. Figure 2-1 shows the general conceptual relationship of background preparation to the core curriculum and the remainder of the track requirements.

The core courses and their prerequisite structure are shown graphically in Figure 2-2. Each course box also contains a reference to the core knowledge topics it covers. In mapping the core knowledge into courses, the authors took advantage of the weight (hours of lecture) assigned to each topic, as described in an earlier publication (6). Each course was developed to carry approximately three quarter-hours of credit (30 hours of lecture).

The figure shows that the courses are distributed among four groups:

Computer science
Health sciences
Integrative studies
Contributing studies

In the computer science and contributing studies areas, we have extracted and reshaped traditional material to meet the needs of the health computing student. In the area of health sciences, we have introduced two new courses -- Health Information and Clinical Decision Making. An examination of the content and approach of Health Information shows that we believe the health computing professional must have an intimate understanding of the nature, quality, and value of health data. Further, Clinical Decision Making is offered to focus the student's attention on current methods of medical decision making and the power of alternative methods. This background in health information and clinical decision making is essential for effective involvement in health information systems.

The third core area -- that of integrative studies -- is perhaps the most critical element of the core curriculum. Our intention is to focus the student's attention sharply on the application, potential, and impact of computer technology in health care. We want the student not only to understand the state of the art of health computing but also to see the state of the art as an early step in the full evolution and integration of computer technology and health care.

The first integrative course, The Health Care Delivery System, introduces the sociological elements of health care into the curriculum, and the second course provides a historical and future perspective of the field. The final pair of integrative courses provides for the selection of about a half-dozen current and promising computer science techniques for in-depth study. Each technique is studied in an

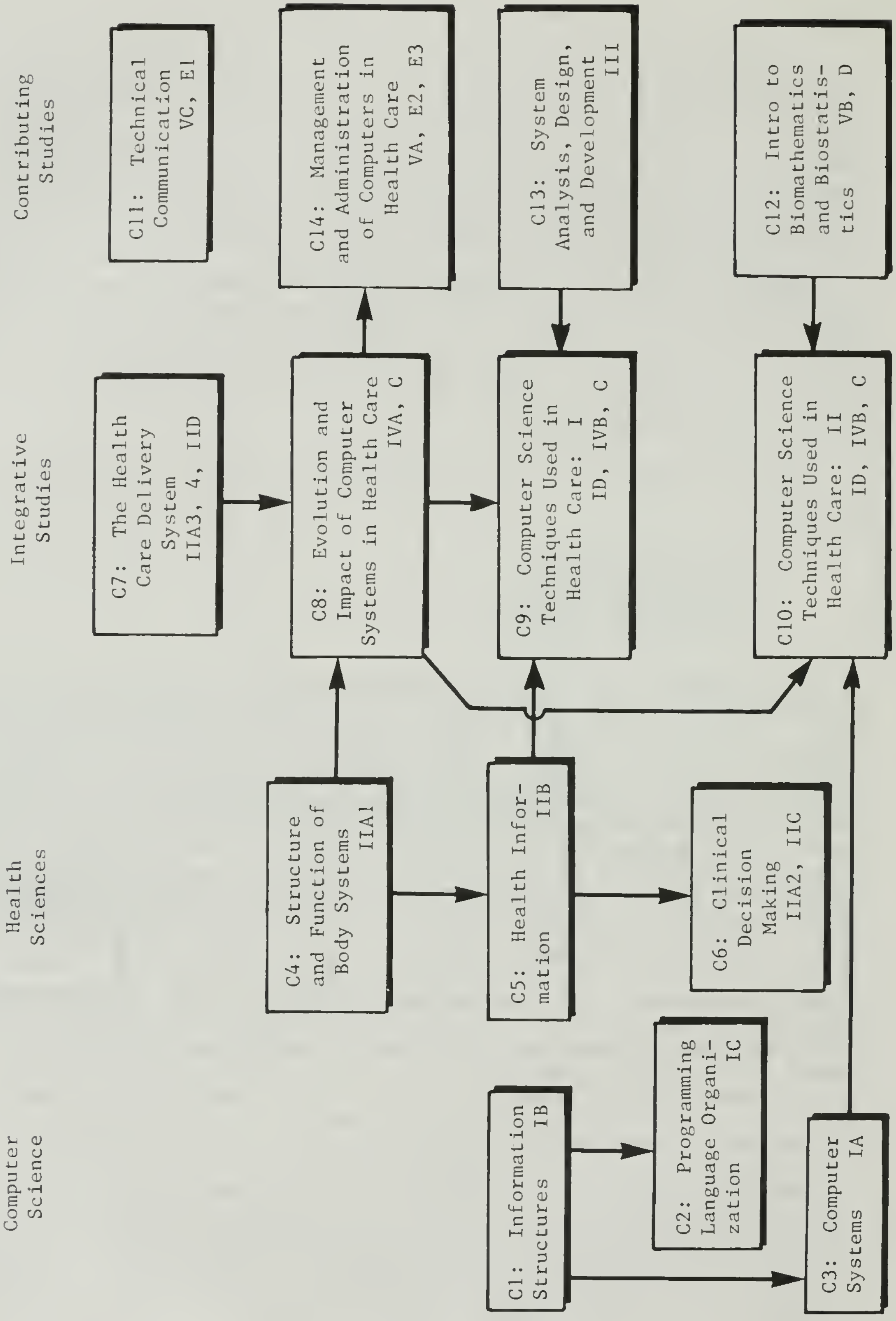

Contributing Studies
Integrative Studies
Health Sciences
Computer Science
C11: Technical Communication VC, E1
C14: Management and Administration of Computers in Health Care VA, E2, E3
C13: System Analysis, Design, and Development III
C12: Intro to Biomathematics and Biostatistics VB, D
C7: The Health Care Delivery System IIA3, 4, IID
C8: Evolution and Impact of Computer Systems in Health Care IVA, C
C9: Computer Science Techniques Used in Health Care: I ID, IVB, C
C10: Computer Science Techniques Used in Health Care: II ID, IVB, C
C4: Structure and Function of Body Systems IIA1
C5: Health Information IIB
C6: Clinical Decision Making IIA2, IIC
C1: Information Structures IB
C2: Programming Language Organization IC
C3: Computer Systems IA

Figure 2-2. Core Curriculum Courses and Prerequisite Structure

integrative manner, combining technical elements, current and potential application, and societal impact. Naturally, as the profession evolves the techniques selected should change as well to provide the student with the most relevant experience in integration. It is very important that the student be well-prepared in computer and health sciences so that these techniques can be studied at an appropriately mature level.

The 14 core courses are described in the next section, and a detailed teaching approach and a listing of the content for each course are given in Appendix B.

2.2 CORE CURRICULUM COURSES

C1 INFORMATION STRUCTURES

Objectives

The course provides an understanding of techniques for handling data and of relationships between physical characteristics of storage media and techniques, as well as experience in implementing techniques, specifically in the context of a database management system.

Description

Introduction to methods of file organization and access. Internal and external sorting and searching techniques. Physical characteristics of storage media. Database management system concepts and implementation.

C2 PROGRAMMING LANGUAGE ORGANIZATION

Objectives

This course enables the student to understand and use techniques for programming language definition, organization, translation, and execution and provides experience in language specification and analysis.

Description

Principles of language design and definition. Effects of language features on run time behavior of programs. Introduction to language translation techniques. Examples using specific languages.

C3 COMPUTER SYSTEMS

Objectives

The course is intended to provide concepts of operating systems and computer architecture and to introduce interrelationships between operating systems and architectures of various types of computer systems.

Description

Concepts of operating systems. Organization and structuring of major components of computers. Data transfer and control within a computer system. Interrelationships between operating systems and architecture.

C4 STRUCTURE AND FUNCTION OF BODY SYSTEMS

Objectives

This course introduces the student to the fundamental principles of general physiology and anatomy, including a systematic discussion of human normal and abnormal physiology.

Description

The physical basis of life, i.e., cells, structure and function of tissues, organs, movement, skeletal system, and muscular system. Integration and coordination. Systems for transport of oxygen and nutrients and their utilization and excretion by the body. Individual characteristics and genetics.

C5 HEALTH INFORMATION

Objectives

The course provides the student with concepts of classification of medical knowledge and an understanding of the sources of patient data and their collection, storage, retrieval, and control. It also provides an appreciation of the limitations of the sources of the information and its reliability, accuracy, and completeness.

Description

Development of the medical record: history, physical, and laboratory data. The tools used to perform a physical and the most common laboratory tests. Nomenclature, terminology, and disease classification. Use of the medical record in care evaluation, education, research, accreditation, and certification.

C6 CLINICAL DECISION MAKING

Objectives

This course introduces the student to the process of clinical decision making in diagnosis, treatment planning, and prognosis.

Description

The clinical decision process for several major categories of disease. Use of subjective and objective information. Alternate models for clinical decision making.

C7 THE HEALTH CARE DELIVERY SYSTEM

Objectives

The course presents an overview of the organization and operation of the current health care system in the United States and describes the public policies and private sector trends and forces that have influenced the development of the current system.

Description

Health care organizations and delivery alternatives. Actors (providers, suppliers, consumers, financiers, regulators). Prevention of disease. Planning and research. Evaluation. Costs, expenditures, and cost containment. Policies, forces, and trends. The role of information.

C8 EVOLUTION AND IMPACT OF COMPUTERS IN HEALTH CARE

Objectives

This course provides a broad understanding of the role and impact computers have had in the health care system and shows the potential for continued integration.

Description

Evolution of computer use in health education, research, clinical information systems, patient care, management, public health, reimbursement, and the regulatory process. Societal issues and technology assessment.

C9 COMPUTER SCIENCE TECHNIQUES USED IN HEALTH CARE I

Objectives

The course introduces the student to selected computer science techniques that are being used extensively in health care and provides awareness of the potential health and health care system implications of using these techniques.

Description

Health care system uses of the computer science techniques of database design, data communications, and systems analysis and design. Societal issues and technology assessment.

C10 COMPUTER SCIENCE TECHNIQUES USED IN HEALTH CARE II

Objectives

The course introduces the student to selected computer science techniques that are being used extensively in health care and provides awareness of the potential health and health care system implications of using these techniques.

Description

Health care system uses of the computer science techniques of analog data aquisition, artificial intelligence, modeling, and simulation. Societal issues and technology assessment.

C11 TECHNICAL COMMUNICATION

Objectives

The course is intended to assist the student in becoming an effective technical communicator through the use of oral, written, and graphic techniques.

Description

Theory and practice in the use of methods of technical communication. Oral, written, and graphic techniques, with emphasis on techniques for briefings and lectures.

C12 BIOMATHEMATICS AND BIOSTATISTICS

Objectives

The course introduces fundamental quantitative concepts and methods.

Description

Introduction to mathematical and statistical concepts and methods relevant to health care.

C13 SYSTEMS ANALYSIS, DESIGN, AND DEVELOPMENT

Objectives

This course is intended to: introduce and develop an understanding of the concepts of general systems theory; present basic design and analysis tools and techniques; develop an in-depth understanding of both organizational and technological aspects of a systems design relevant to a health computing setting.

Description

Introduction to the systems concept and the systems analysis process. Basic design and analysis tools. Criteria for hardware and software evaluation and selection. Case studies of the systems analysis and design processes.

C14 MANAGEMENT AND ADMINISTRATION OF COMPUTERS IN HEALTH CARE

Objectives

The course presents project management and those aspects of systems analysis used in management practice and examines behavioral dynamics, organizational change, and conflict principles as related to organization and management of systems, projects, and programs in health care organizations.

Description

Project management theory and techniques. Cost estimating and budgeting, planning, control, monitoring, and evaluation. Interpersonal and group behavior. Conflict management. Organizational change.

3 SPECIALIZATION TRACKS

3.1 TRACK CONCEPTS

The recognition of specialty tracks underscores the scope of computing technology's impact in health care delivery. Professionals in careers as remote from direct patient care as basic research or federal health policy formation can have a profound effect in the health care delivery system and thus on the health of the nation and even the cost of health care. Therefore it is important that the full spectrum of health computing professionals, including commercial providers of health computing services, fully understand their responsibilities and opportunities in order to fulfill their potential as professionals.

The four tracks presented in this document represent a convenient grouping based on the common training requirements of certain careers. As noted earlier the four tracks are not meant to be mutually exclusive courses of study; some careers may require training that uses concepts and courses from more than one track. For example, an aspiring health computing training program director, in addition to his or her own research interests, might add courses from the education and administration tracks. Or a potential medical computing scientist who wants to design diagnostic patient monitoring systems might study topics in both the health information systems and health research computing tracks, with elective work in engineering and a clinical science. As the profession evolves, new tracks undoubtedly will be needed and new ways to consider training for existing careers will become evident.

The tracks, as illustrated in this document, are directed toward education of professionals who will be equipped to conduct or foster applied research and who will provide leadership in the practical integration of the underlying disciplines of health computing. For education of individuals who want careers in basic research in the highly technical aspects of each track, the track requirements should be adjusted to meet the academic requirements of an appropriate Ph.D. program.

3.2 PRESENTATION OF THE TRACKS

In the remainder of this section the four tracks are described in greater detail. We attempt to provide the reader with a better understanding of the intent of each track, and we describe several careers that should begin with training in that track. Then requirements for each track are cast into a program of required and elective courses, field work, practica, and thesis research and writing. A prerequisite chart for required courses is provided as a further guide to the reader, and each course is accompanied by an abbreviated description of its content and the recommended teaching approach.

The following prefix notation is used to denote and distinguish the courses in the various tracks and the core courses:

C	Core Courses
IT	Information Systems Track Required Courses
IE	Information Systems Elective Courses
RT	Research Track Required Courses
RE	Research Elective Courses
ET	Education Track Required Courses
EE	Education Elective Courses
AT	Administration Track Required Courses
AE	Administration Elective Courses

To further emphasize the overlapping nature of the tracks, several specific courses from each of the other tracks are strongly recommended as electives, as appropriate for the student's career choice. In one case the required track courses overlap as well.

Following the course descriptions for each track, a sample curriculum implementation plan based on the quarter system is given to show how the requirements (including core courses) could be met in three and a half to four calendar years of full-time study. The sample plan takes into account the prerequisite structure of both core and track courses and a subjective assessment of the difficulty of course material and relationships among concurrent courses. The reader is cautioned that these are sample implementations only, intended to be used solely as guides.

3.3 HEALTH INFORMATION SYSTEMS

3.3.1 The Health Information Systems Specialist

Computer-based information systems have widespread application in a variety of settings in the medical and health care fields. Their use ranges from support systems for departments in a hospital such as a clinical laboratory or a pharmacy to hospital-wide information/communication systems, and from heavily clinical systems to interinstitutional statistical ones. Computer systems can also play a vital role in emerging areas such as clinical decision making, for which programs utilize databases and/or sets of rules to assist health care professionals in diagnosis and in determining appropriate patient care.

There is a growing need for persons who have the capabilities and background to provide technical leadership in the design and implementation of computer-based health information systems for the varied applications areas. These systems must be reliable, easy to learn and use, and adaptable to changes in health system needs or computer technology. Their development requires persons with an in-depth knowledge of specific areas within computer science, software engineering, systems engineering, and health care, and of the sociology of the health care environment or system.

The health information systems specialization within the health computing curriculum provides training for those who will function primarily as planners, designers, and implementers of computer-based information systems. It combines detailed study in computer systems and languages with extensive training in appropriate aspects of medicine, health care, and the use of computers in that setting.

3.3.2 Careers

The range of alternative career paths from which to choose in this specialization is broad. One career currently available is a hospital administrative staff position in a medium- to large-sized hospital, or a system of hospitals, with responsibility for the variety of patient information processing applications that must be carried out. Such a position would involve the information systems specialist in planning, designing, and implementing in-house systems and user training, as well as in facilities evaluation and selection of computer equipment and services. The health information systems specialist might be the head of a medical computing department or a project manager in a very large institution. The specialist could also act as a technical consultant on major projects headed by health computing administrators.

Such a hospital-based role is only one alternative for the information systems specialist. Another typical alternative would be to follow a career path in the computing industry. There are a large number of companies supplying software packages, turnkey systems, time-sharing services, hardware, and other related products or services for health computing applications. The range of applications extends from specialized terminal devices through systems that support hospital departments such as the clinical laboratory or the pharmacy to integrated intra- and interinstitutional systems of health databases.

The health information systems specialist could join one of the many companies engaged in this business or could help to form a new company, increasingly more frequent in this field, benefiting both from the availability of microcomputer systems and from the cottage industry nature of health computing companies. In an industrial setting this specialist would have to apply knowledge of the health computing environment in planning and developing appropriate marketable, cost-effective systems. There would be a strong need to apply systematic software development techniques and to use sophisticated methods for program quality assurance, perhaps including formal verification for those systems that will be applied in life-critical settings.

The field of clinical decision making offers promising career opportunities as well. The development of sophisticated systems in this field necessitates requiring a greater medical background (e.g., an M.D. degree) as an elective emphasis. For those who are well-grounded clinically, this field offers the closest association with the physician-patient relationship.

Another possibility for this specialist is medical information systems research, either in an industrial research setting or within a university. Technical information systems research might focus on specialized human-machine interfaces, database design, or development of artificial intelligence applications.

3.3.3 The Health Information Systems Model Curriculum

3.3.3.1 General Requirements

The health information systems specialization includes specific topics that integrate the computer and health fields, opportunities to pursue an area in more depth or to choose an additional area, and practical experience in an actual applications setting. Students in the health information systems specialty must complete:

a) The core curriculum.

b) 27 credit hours of specialty-track course work and a minimum of 18 credit hours of electives. Specialty courses have been developed that would provide an adequate background. A list of these is shown in Table 3-1, and the course descriptions are given below. The sequencing of the courses is shown in Figure 3-1.

c) 6 months (two quarters) of field experience in a hospital or a health organization setting. This practicum should be accompanied by a seminar to discuss and share experiences.

d) A thesis based on, for example, research and analysis of a major information systems application in the health care system or the design and/or development of a health information system. A maximum of 30 hours of credit for thesis research and writing should be allowed.

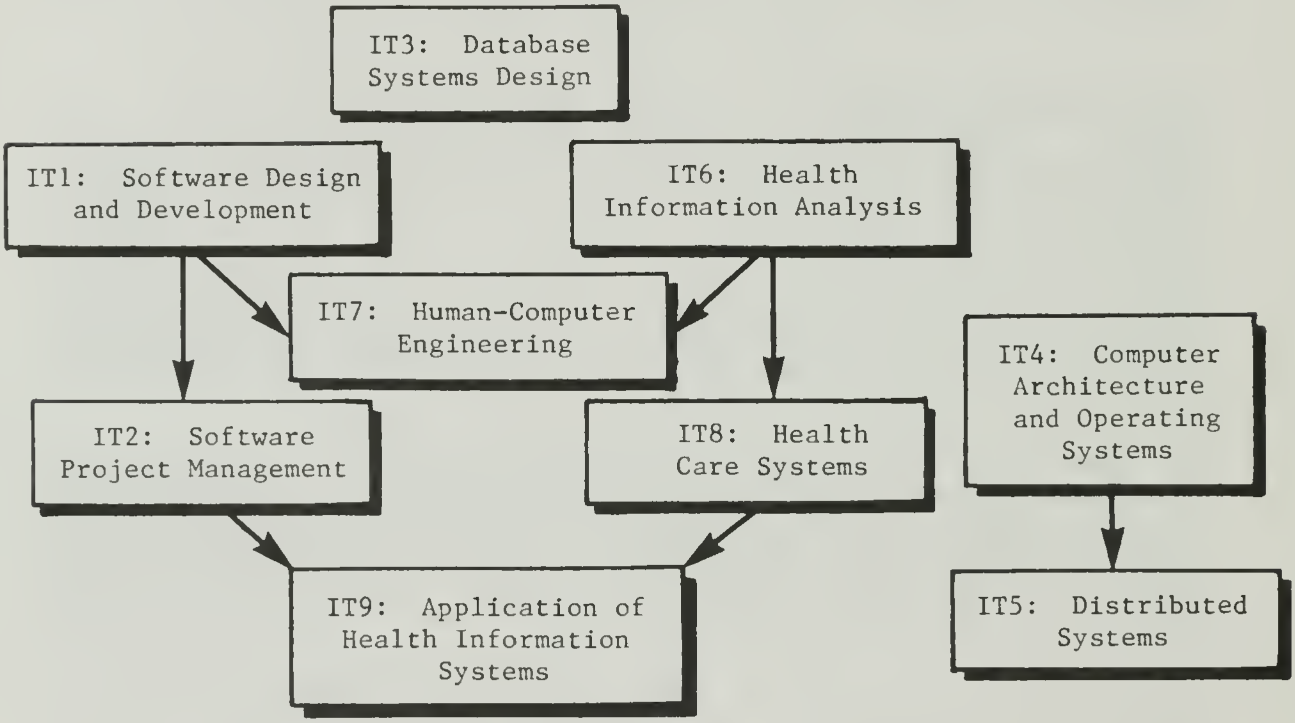

IT3: Database Systems Design
IT1: Software Design and Development
IT6: Health Information Analysis
IT7: Human-Computer Engineering
IT4: Computer Architecture and Operating Systems
IT2: Software Project Management
IT8: Health Care Systems
IT9: Application of Health Information Systems
IT5: Distributed Systems

Figure 3-1. Health Information Systems Course Sequence

Course No.	Task	Credit Hours
IT1	Software Design and Development	3
IT2	Software Project Management	3
IT3	Database Systems Design	3
IT4	Computer Architecture and Operating Systems	3
IT5	Distributed Systems	3
IT6	Health Information Analysis	3
IT7	Human-Computer Engineering	3
IT8	Health Care Systems	3
IT9	Application of Health Information Systems	3

Table 3-1. Health Information Systems Specialty Track Courses

3.3.3.2 Course Descriptions

IT1 SOFTWARE DESIGN AND DEVELOPMENT

Prerequisites

Computer Languages (C2); Computer Systems (C3); System Analysis, Design, and Development (C13)

Objectives

This course is designed to present the tools and techniques relevant to the systematic design and development of computer software; to illustrate problems in applying design techniques to meet user needs; to provide experience in evaluating methods for and quality of design of software and systems; and to provide insights into the effects of programming languages and other tools on the overall software development effort.

Approach

Software Design and Development forms a two-course sequence with Software Project Management (IT2) in concepts and techniques for solving significant problems through the use of up-to-date software design and development methodology. Laboratories are held in conjunction with lectures in both courses to provide more time for practical experience and discussion of realistic problems, especially those relating to the creation and maintenance of efficient operational health information systems. Students should work in teams on programming projects. Programming should be done according to the discipline and style requirements of structured programming, including good documentation.

Within the two courses students are exposed to the entire systematic process from problem statement to readable, maintainable software that meets user needs. Students not only are required to participate in this process as members of teams but are also expected to understand the various aspects of managing the process.

A large software project, such as the design and development of a hospital information system (or some significant portion of one), could be used as a context for the introduction of topics in lectures. In addition, groups of students should be assigned substantial projects that require implementing the techniques and concepts discussed in the course so that they not only will be exposed to them but will also experience their implementation in an appropriate setting.

Systems analysis techniques are used, including user needs, problem statements, analysis methods, formulation of requirements definition, interviewing, user validation of specifications, and trade-offs in requirements. Approaches to specification of system characteristics are discussed, including algebraic specifications, specification languages, and goals (e.g., completeness, consistency, comprehensibility, preciseness, and modifiability). Software and system design topics such as transformation of specification of design, problem decomposition and modularization, design trade-offs and methods, design representation and review, program design languages, and modeling are stressed. Aspects of the programming process should be included, such as choice of languages, programming style, implementation strategies, software tools, software validation, performance analysis and improvement, testing strategies, and program verification. Management of software development should be emphasized, including such concepts as budgeting and estimating, project team organization, project milestones, documentation and code standards, progress review, configuration management, and introduction of new software practices.

Content

Overview of software engineering and software life cycle (5%). Analytical tools (10%). System analysis activities and techniques (20%). Requirements analysis (10%). Specifications (15%). Process, techniques, tools, and verification of software and systems design (20%). Implementation strategies and tools (10%). The programming process (10%).

IT2 SOFTWARE PROJECT MANAGEMENT

Prerequisite

Software Design and Development (IT1)

Objectives

The course enables students to use the tools and techniques of software verification, validation, and maintenance effectively; provides an introduction to system performance measurement and modeling; provides basic knowledge of organizational structures, of the roles of software development, computers, and personnel within them, and of techniques for planning and organizing software projects.

Approach

See Software Design and Development (IT1)

Content

Verification and validation (15%). Testing and maintenance (20%). Human-machine interaction, including security and protection measures and privacy issues (20%). Techniques for performance evaluation, measurement, and analytical modeling (20%). Management considerations such as organizational structure; software project planning, organization, monitoring, and control; personnel issues; user interactions; legal aspects (25%).

IT3 DATABASE SYSTEMS DESIGN

Prerequisite

Computer Systems (C3)

Objectives

The course provides concepts and structures necessary for the design and implementation of a database management system; presents fundamentals of administration of a database management system and insights into user-machine interface problems.

Approach

Students working in teams are required to design and implement a simple database management system, including at least file security and a query facility. Design considerations specific to various types of health databases are stressed. Design and implementation techniques are emphasized along with such relevant concepts and structures as physical file organization, data organization and models, data integrity, file security, and user-machine interactions. Concerns related to the administration of database systems are discussed.

Examples should be drawn from health information systems, where possible, and students should experience the use of a specific system. A laboratory could accompany this course.

Content

Basic database concepts (5%). Hierarchical, network, and relational models (10%). Logical and data structure representations of database systems (5%). Data description languages and query facilities (20%). File and index organizations (25%). File security (10%). Data integrity (5%). Interfaces among user, system, access methods, and databases (10%). Administration concerns (10%).

IT4 COMPUTER ARCHITECTURE AND OPERATING SYSTEMS

Prerequisite

Computer Systems (C3)

Objectives

The purpose of this course is to study the organization and structure of operating systems for various modes of computer use (e.g., batch, time-sharing, multiprocessing); to study the structure, implementation, function, and management of processors, memory, files, and input/output devices; and to provide hands-on experience in designing and writing portions of operating systems.

Approach

The two-course sequence of Computer Architecture and Operating Systems and Distributed Systems (IT5) covers in greater depth many of the topics introduced in Computer Systems (C3). Emphasis is given to multicomputer systems such as networks or distributed systems, as well as to intrasystem communication. Economic considerations and modeling of systems are also discussed. Where possible, students should have access to a small computer (mini- or microcomputer) to implement operating systems concepts. This could be achieved either through separate laboratories in conjunction with the courses, or by making a facility available and requiring students to use it on their own time to complete projects assigned in the courses.

Throughout the courses the interrelations of operating systems designs and architectures should be exemplified both in class demonstrations and by having groups of students design and write simple operating systems segments, for example, to manage memory, input/output, or interrupts. Actual design specifications could be provided to students for this purpose. Software considerations involved in a distributed system are also discussed. Communication concerns, including protocols and costs, are emphasized. Specific examples of existing distributed systems/networks should be discussed in sufficient detail to enable students to grasp the design techniques and trade-offs of the systems and the implications of various alternatives.

Content

Architecture: input/output processors, processor-memory communication, memory addressing, microprogramming, and parallel and pipelined computers (40%). Operating system design: concurrent processes, name management, resource allocation strategies and evaluation, and protection (40%). Mini/microcomputer systems and multiprocessing/multiprogramming systems (20%).

IT5 DISTRIBUTED SYSTEMS

Prerequisite

Computer Architecture and Operating Systems (IT4)

Objectives

The course analyzes and evaluates design techniques of architecture and software for distributed systems and describes methods for communication within distributed systems.

Approach

See Computer Architecture and Operating Systems (IT4)

Content

Review of architecture and operating system design (10%). Distributed systems/networks: operating systems issues, modeling and design techniques, trade-offs and alternatives, security, types of distributed systems, and communication protocols (40%). Data communication: analysis, modeling and design of data communication systems and networks, protocols, implementation in local networks and satellite systems, and communications hardware architecture and software (40%). Health system issues and economics (10%).

IT6 HEALTH INFORMATION ANALYSIS

Prerequisites

Computer Science Techniques Used in Health Care (C9 and C10); Health Information (C5)

Objective

This course provides an in-depth assessment of quality, interpretation, and use of health data, with special emphasis on patient care and quality assurance.

Approach

Students analyze sequentially the data elements used in the health care system for such factors as quality, social and clinical significance, and alternative methods of obtaining information; relative size, volume, and frequency of collection and volatility of data elements; amount and variety of use and interrelationships of data elements; and problems of standardization, aggregation, and release of data. To provide different viewpoints, students' individual or small-group analyses should be compared and discussed. Special attention is given to an assessment of the value of data elements for patient care and other uses. Students should use directed reading, interviews, and observation as the basis for their analyses.

Content

Hospital-generated information: analysis of history, physical, laboratory data, orders, nursing and progress notes, discharge summaries, and nonclinical data (50%). Hospital information flow: quantitative and qualitative assessment of the progressive acquisition and routing of information, with special emphasis on duplication and opportunity for error (15%). Posthospitalization use of information: record abstracting and coding, actual versus possible use in medical audit, quality assurance, research, education, management, accreditation, credentialing, and privacy (15%). Out-patient records: analysis of physician's office versus emergency facility versus clinic information handling, value of information in a time-based versus a problem-oriented record, and concept of a single lifetime health record (10%). Alternative approaches: redundancies and deficiencies in current information, benefits and problems of aggregation and brokering of information among institutions in the health care system (10%).

IT7 HUMAN-COMPUTER ENGINEERING

Prerequisites

Software Design and Development (IT1); Health Information Analysis (IT6)

Objectives

This course provides an understanding of the capabilities, organization, and implementation of user languages and the limitations of existing procedure oriented languages for use in health computing applications; knowledge about user interface tools and techniques; and an appreciation of the psychophysiological aspects of computer use.

Approach

The basic premise of this course is that computer systems will be commercially viable only to the extent that the user interface is in harmony with user skills and task requirements. Thus the approach is to develop through lectures, directed reading, case studies, and field experience a knowledge of strengths and weaknesses of existing user oriented tools (both languages and computer components), as well as an understanding of the psychological and physiological aspects of user interface with the kinds of computer systems/components normally found in health care settings.

Content

Design characteristics and implementation concerns of user oriented interactive and query languages (40%). Limitations of algorithmic and procedure oriented languages for health computing use (20%). Concepts of personal computing (10%). User concerns in graphics, innovative input/output devices, word processing, text editing, integrated systems (30%).

IT8 HEALTH CARE SYSTEMS

Prerequisite

Health Information Analysis (IT6)

Objectives

The course reviews the structure and function of the current health care delivery system from the point of view of how information does, or may, flow in the system and influence health care trends. Emphasis is on extra-institutional regional and national information flow; constraints, underutilization, and overutilization of information; multipurpose information; regional and national needs; organization of distribution systems; social implications of general availability of health information.

Approach

Insight into current information flow is obtained by directed reading, field trips, and interviews. Other course concepts are explored through directed reading, group discussion, and individual or small group conceptual design projects.

Content

Medical care: lifetime medical record, PSRO, clinical research, and monitoring for environmental and adverse treatment effects (20%). Regional and national planning: HSAs, CHSS, national health services, and worldwide epidemiologic and other public health uses (25%). Education: undergraduate and postgraduate education; credentialing and relicensure; continuing education and training; and decision aids (10%). Financial: third-party payment; rate setting; Medicare-Medicaid; National Health Insurance; and cost containment (15%). Advanced concepts of information flow for the health care delivery system: institutional reporting interfaces; integrated information flow; regional and state data centers; a national health information system; problems of standardization; social implications; and concepts of data brokering (30%).

IT9 APPLICATION OF HEALTH INFORMATION SYSTEMS

Prerequisites

Software Project Management (IT2); Health Care Systems (IT8)

Objectives

This course provides students with experience in the study and analysis of all aspects of an actual health information system.

Approach

The course involves a case study approach. One or more applications are analyzed in detail, including design considerations, system life cycles, cost estimates, societal value, technical analysis, software implementation, and equipment considerations. One or more field trips should be taken, as appropriate. Students are expected to take an active part in the course, either through seminar-like presentations on specific aspects of the application or through role playing within the context of the application, in addition to doing at least one substantial written analysis.

Content

An in-depth study of one or more actual health information systems within a hospital or health care organization environment (100%).

3.3.3.3 Electives

A program of elective courses should be selected to reflect the student's intended career path. Courses from the other tracks that strengthen the student's general preparation are especially recommended, in addition to further study in computer science or the health sciences, as necessary. The recommended general areas and specific courses are listed in Table 3-2.

Area	Course Title
Other specializations within the health computing curriculum	CAI Systems (ET6) CMI Systems (ET8) Experimental Design (RT3) Digital Signal Analysis (RT5) Numerical Computation in Health Science Research (RT6) Analog and Hybrid Computation (RE1) Hospital Organization and Management (AT1) Legal Environment of Health Computing (AT4) Information Analysis and Decision Making Techniques (AT5)
Advanced courses in computer science	Systems Database Applications Software Development Artificial Intelligence Simulation
Courses in other areas	Business and management Modeling Operations Research Probability Statistics Medical or Allied Health Programs

Table 3-2. Health Information Systems Electives

3.3.4 An Example Implementation

The time needed to complete the curriculum varies, depending on course load, use of summers, sequencing of courses, field experience selected, and nature of the thesis. One possible implementation of the entire set of requirements is shown in Table 3-3 as an example.

A very technically oriented student in this sample curriculum might choose as electives additional advanced courses in computer science and a clinical field experience in developing and implementing clinical user specifications for a human-machine interface in a hospital setting. A management oriented student might select elective courses from the Health Computing Administration track, statistics, and operations research offerings and assist in long-range facilities planning for hospital information systems as a clinical experience. An individual interested in clinical research or decision making might pursue an elective M.D. or an allied health degree.

These examples are given to illustrate the range of possible options for study under a health information systems specialty program. In every case, however, the student should become competent in the areas indicated by the nine track (IT) courses.

	Year			
Quarter	1	2	3	4
1	C1 C4 C7 C11	C10 IT4 IT6	IT9 Elective Elective	Elective Thesis
2	C2 C3 C5	IT1 IT5 Elective	Clinical experience	Thesis
3	C6 C8 C12	C14 IT2 Elective Elective	Clinical experience	
4	C9 C13 IT3	IT7 IT8 Elective	Elective Thesis Thesis	

Table 3-3. Example of a
Health Information Systems Curriculum Plan

3.4 HEALTH RESEARCH COMPUTING

3.4.1 The Health Research Computing Specialist

Traditionally research in the health sciences has taken place within the setting of the medical, dental, nursing, pharmacy, or allied health environment. The nature of much of this research is changing as advanced technology is introducing new and powerful tools for performing sophisticated research data acquisition and analysis of results. Problems that previously required days, weeks, or even months to solve can now be performed quickly, economically, and accurately. Software tools for modeling, simulation, and research databases have opened up new frontiers of research methodology as well. The majority of researchers, both basic science and clinical, are ill equipped to use these tools; thus valuable time is lost trying to obtain new skills and knowledge. In many instances a collaboration is arranged with someone better equipped in computing but equally ill equipped in the required area of health research, but such a symbiosis inevitably leads to a less than successful effort.

There is a definite need for individuals with the qualifications to satisfy these computing needs within the traditional organizational framework of health science institutions. These needs include sufficient training in computing to allow for its use in independent research, as well as an expertise to teach satisfactorily in an area of health science to fulfill the specific needs of a traditional basic science or clinical department or unit. A small population of researchers has these qualifications now, but these individuals have evolved by a heuristic or even serendipitous route, rather than through organized formal programs especially designed to provide this urgently needed training. In addition to competency in computer and quantitative sciences, it is necessary for graduates of programs in health science computing, especially those interested in health research, to be so prepared that they are attractive, potentially valuable members of the health science team.

3.4.2 The Health Research Computing Model Curriculum

3.4.2.1 General Requirements

The research specialty track of the curriculum is intended for individuals pursuing either basic science or clinical research that has computing as an integral component. It is clear that because of current legal constraints, most individuals specifically interested in doing independent research in a clinical area will have a medical degree or will be pursuing such a degree concurrently. In either case, students in the research specialty must complete:

a) The core curriculum and calculus.
b) 34-39 credit hours of specialty track course work and a minimum of 15 credit hours of electives. A list of specialty track courses that have been developed are given, along with the credit hours, in Table 3-4. Course descriptions are given below. Sequencing of the required courses is shown in Figure 3-2. Note that the list of required courses includes studies in a basic or clinical science sufficient to qualify the student in that discipline. It is assumed that the student achieves the equivalent of a practicum as a by-product of studies in the health sciences.
c) A thesis based on results obtained from research and experiments related to a specific health care problem, based in one or more basic or clinical science areas. A maximum of 36 hours of credit for thesis research and writing should be allowed.

Course No.	Title	Credit Hours
RT1	Advanced Basic or Clinical Science	15-20
RT2	Electronics for Biological Scientists	4
RT3	Experimental Design	3
RT4	Linear and Nonlinear Models in Health Science Research	3
RT5	Digital Signal Analysis	3
RT6	Numerical Computation in Health Science Research	3
RT7	Biomedical Instrumentation and Laboratory Computing	4

Table 3-4. Health Computing Research Specialty Track Courses

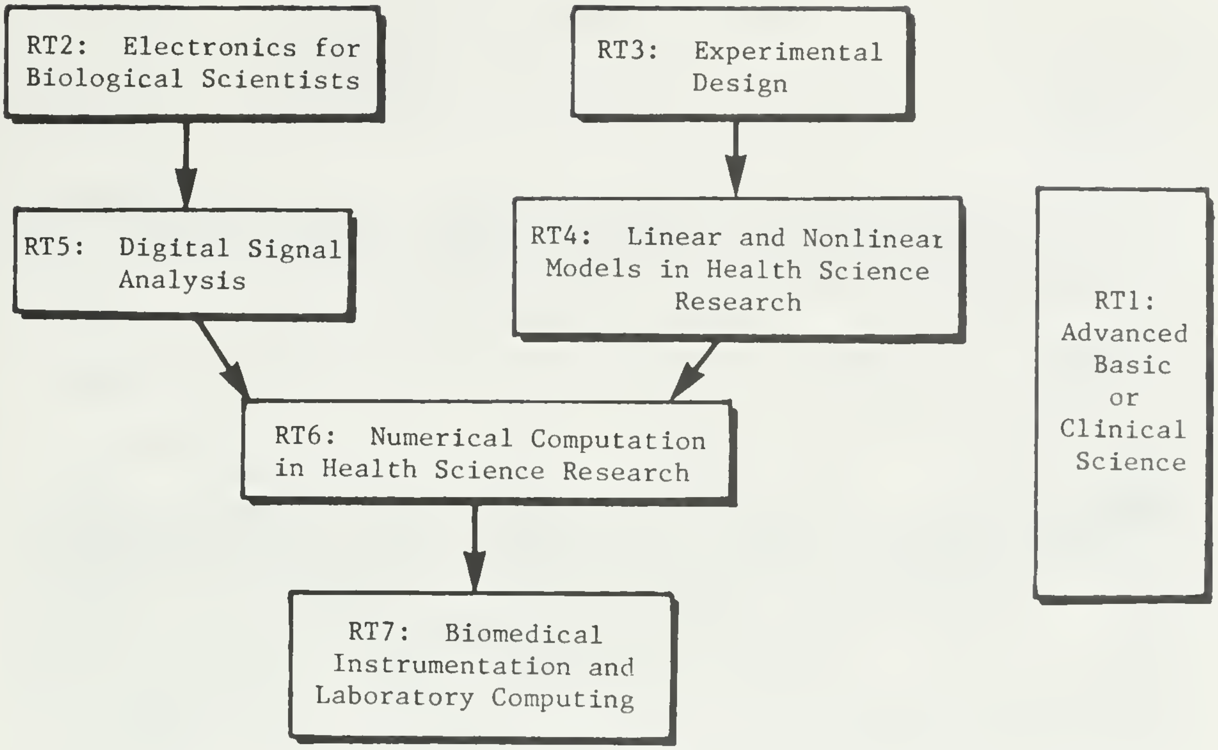

RT2: Electronics for Biological Scientists
RT3: Experimental Design
RT5: Digital Signal Analysis
RT4: Linear and Nonlinear Models in Health Science Research
RT1: Advanced Basic or Clinical Science
RT6: Numerical Computation in Health Science Research
RT7: Biomedical Instrumentation and Laboratory Computing

Figure 3-2. Health Research Computing Course Sequence
(Note: RTI represents a 15-20 credit-hour sequence
of courses. See Table 3-6 for an example implementation.)

3.4.2.2 Required Courses

RTI ADVANCED BASIC OR CLINICAL SCIENCE

Prerequisite

Structure and Function of Body Systems (C4)

Objectives

The course should provide doctoral-level training and education in one or more of the basic or clinical sciences, such as pharmacology, physiology, biochemistry, or cardiology.

Approach

Credit for this course should be obtained through a standard series of courses provided in a Ph.D. program in the selected basic or clinical science. In some cases course sequences from an M.D. program may be used to meet this requirement.

Content

Depends on field of study.

RT2 ELECTRONICS FOR BIOLOGICAL SCIENTISTS

Prerequisite

None

Objectives

The course provides the basic concepts of analog and digital electronics and applies these concepts to the design, analysis, and testing of electrical and electronic circuits and instruments.

Approach

The course consists of 2 hours of lecture and 4 hours of laboratory per week. Grades are based on laboratory work and written examinations.

Content

Basic electricity (10%). Power supplies (10%). Amplifiers (10%). Oscillators (10%). Comparison measurements and operational amplifiers (10%). Introduction to digital circuits and semiconductor devices (10%). Digital logic circuits and digital integrated circuits (10%). Boolean algebra, flip flops, and registers (10%). Sequential logic circuits and combinational logic circuits (10%). Digital design and digital applications (10%).

RT3 EXPERIMENTAL DESIGN.

Prerequisite

Introduction to Biomathematics and Biostatistics (C12)

Objectives

This course enables students to choose optimal research designs and to approach the analysis and interpretation of data from selected research designs.

Approach

Lectures on the theory and practice of experimental design, weekly assignments relating to health research, and a minimum of two projects, including responsibility for the design and analysis.

Content

Analysis of variance techniques (15%). Block and Latin-square designs (15%). Factorial experiments and repeated measurement (15%). Linear, polynomial, and exponential regression (15%). Multivariate analysis (15%). Analysis of covariance (10%). Transformations and estimation of missing observations (5%). Sequential analysis (5%). Response surfaces (5%).

RT4 LINEAR AND NONLINEAR MODELS IN HEALTH SCIENCE RESEARCH

Prerequisite

Experimental Design (RT3)

Objectives

This course provides students with the tools for developing and analyzing linear models to describe functional relationships in health science. It also provides an introduction to nonlinear models, and it gives the student experience in the use of modeling in health research.

Approach

Lectures on the theory underlying selected models. Weekly assignments applying selected concepts to relationships in health science research. Course should include real or simulated data collection for empirical development of models.

Content

Mathematical and statistical concepts (10%). Quadratic forms (10%). Multivariate normal distribution (10%). General linear hypothesis of full rank (10%). Functional relationships (10%). Regression models (10%). Experimental design models (10%). Variance components (10%). Mixed models (10%). Nonlinear models (10%).

RT5 DIGITAL SIGNAL ANALYSIS

Prerequisite

Electronics for Biological Scientists (RT2)

Objectives

The course teaches various digital filter design techniques so that the student can design and implement digital filters on a digital computer; teaches recognition of signal and noise problems; provides understanding of Fourier transforms by using the transforms to discuss spectral, autocorrelation, and cross-correlation analysis.

Approach

Each student has projects requiring the design and implementation of digital filters; the use of Fourier transforms to analyze the frequency components of a biomedical signal; and smoothing, auto- and cross-correlation, and spectral analysis of digital signals in ongoing biomedical research.

Content

Discrete systems by difference equations (10%). Z and Inverse-Z transforms (10%). Solution of difference equations by Z transforms (10%). Techniques of digital filter design, including frequency sampling and impulse invariance techniques (20%). Quantification effects on digital filters (10%). Discrete Fourier transforms (10%). Fast Fourier transforms (10%). Spectral density estimation (10%). Auto- and cross-correlation (10%).

RT6 NUMERICAL COMPUTATION IN HEALTH SCIENCE RESEARCH

Prerequisites

Linear and Nonlinear Models in Health Science Research (RT4); Digital Signal Analysis (RT5)

Objectives

The course enables the student to estimate the numerical errors of any computer operation and its results; understand algorithmic languages and the limitations of existing programming packages; fit equations to various data and interpret them; solve algorithmic and differential equations numerically. In addition, it provides an awareness of and practice in the principal numerical methods for obtaining quantitative results from models in the biological and health care delivery fields.

Approach

Lectures and assignments from the health sciences, requiring use of the computer to illustrate each technique studied. The student should also prepare a term paper verifying published numerical calculations from medical research literature.

Content

Random number generation (10%). Types of errors and error analysis for a digital computer (5%). Numerical solutions of nonlinear algebraic equations (10%). Numerical solutions of systems of nonlinear algebraic equations (10%). Numerical solutions of real and complex roots of polynomials (10%). Numerical solutions of systems of linear algebraic equations (10%). Curve fitting and interpretation (10%). Finite difference calculus, its application and interpretation (10%). Numerical differentiation and integration and their associated errors (10%). Numerical solution of differential equations and systems of differential equations (10%). Boundary value problems in ordinary differential equations (5%).

RT7 BIOMEDICAL INSTRUMENTATION AND LABORATORY COMPUTING

Prerequisite

Numerical Computation in Health Science Research (RT6)

Objectives

This advanced course provides the opportunity to synthesize clinical or basic science objectives with quantitative and instrumentation skills in the design and simulated testing of an instrumentation system of practical value in health care research. The course should enable the student to demonstrate the ability to design an instrumentation system incorporating computation that will meet specific research and/or clinical objectives. The design must include such considerations as a safe and effective power-distribution system, appropriate data collection methods, acceptable precision and accuracy of data, reliability and appropriateness of calculations, system stability, feedback, and quality control. The student must be able to design test systems, accomplish or simulate measurements, analyze the data, and determine whether the system is acceptable for use in meeting the objectives.

Approach

Following review lectures, faculty assist the student in selecting a problem. The student submits a term paper containing the problem statement and justification, background reading, approach, design, test results, etc.

Content

Sources of information in science and biomedical engineering (10%). Review of electronics, experimental design, digital logic, and signal processing and analysis (15%). Review of data handling and sources of error (10%). Systems analysis and design (15%). Instrument components (10%). Interfacing (10%). Hardware and software fundamentals for on-line computer interfacing (10%). Testing and analysis (20%).

3.4.2.3 Electives

Two types of electives are recommended. First, almost all students will select several additional health research computing courses. These courses may be from a health science field, or they may be predominantly mathematical or engineering oriented, depending on the student's research objectives. Students who want to do basic research in biomedical computing may require additional emphasis in more than one elective area to achieve their goals.

Students may also select electives from the other health computing curriculum tracks to reflect their information system, teaching, or management interests. Several specific courses recommended for the two types of electives are listed in Table 3-5.

Area	Course Title
Advanced Health Research Computing	Analog and Hybrid Computation (RE1) Multivariate Methods in Biology and Medicine (RE2) Analysis of Linear Biological Systems (RE3) Analysis of Nonlinear Biological Systems (RE4) Stochastic Biologic Processes: I (RE5) Modeling and Simulation in Health Research (RE6)
Other Health Computing Areas	CAI Systems (ET6) CAI Lesson Development (ET7) Software Design and Development (IT1) Database System Design (IT3) Computer Architecture and Operating Systems (IT4) Information Analysis and Decision Making Techniques (AT5)

Table 3-5. Health Research Computing Electives

3.4.3 An Example Implementation

The choice of advanced Basic or Clinical Science studies or M.D. preparation to satisfy Course RT1 will depend on the career path the student has chosen. A student interested in cardio-pulmonary diagnostic research, for example, could use a substantial portion of the preparation for the M.D. degree to meet RT1 requirements. A student intending to do research in physiology, for example, would be required to take the physiology course work for a Ph.D. in physiology to satisfy RT1 requirements. A complete sample curriculum plan is shown in Table 3-6. The time required to complete the curriculum will vary depending on acceptable course load, the. nature of RT 1, use of summers, course sequence, and the nature of the thesis.

It is recommended that most electives be drawn from the advanced health research computing electives and from other health computing track courses. Some students may also require advanced quantitative courses or specialized health science courses relating to their research.

	Year			
Quarter	1	2	3	4
1	C1 C4 C7 C12	C10 RT1 RT3	Elective Elective Thesis	Thesis
2	C2 C5 C11 RT1	C14 RT4 RT5	Elective Thesis	Thesis
3	C3 C6 C8 RT2	RT1 RT6 Elective	Elective Thesis	
4	C9 C13 RT1	RT1 RT7 Elective	Elective Thesis	

Table 3-6. Example of a Health Research Computing Curriculum Plan

3.5 EDUCATION AND HEALTH COMPUTING

3.5.1 The Health Educational Computing Specialist

The use of computers has widespread application in all phases of the health educational system, including instructional, information resource, research, and management uses. The computer may be used for such diverse instructional activities as review of basic information, tutorials, simulated clinical situations, patient management problems, use of patient databases for teaching purposes, and access to health knowledge bases. It may be used in testing and evaluation to measure competencies or to identify knowledge gaps and prescribe appropriate remediation, either by the student for self-evaluation or by organizations with responsibility for certifying competency and credentialing. Computer-based educational information systems may be used to manage a health professional's lifelong learning experiences, from application for initial professional education through continuing education as a practicing health professional. Computer-based educational databases can likewise be used as a rich resource for educational research, or as unique databases established to be manipulated as needed.

The person who wishes to function in this arena must have considerable educational skills in addition to knowledge in health and computer science and the integrated core skills. A thorough grounding in the basic educational areas of instructional design, curriculum, and evaluation is mandatory, as well as an in-depth understanding of the health educational system in all its facets. An expert working knowledge in the application of computer technology to educational situations is also essential. Since this person will almost always be functioning as a member of a team, interpersonal skills and the ability to communicate effectively both orally and in writing are critical.

3.5.2 Careers

The specialist in health educational computing will most likely be found working within an educational institution in one of the following roles: teacher of students who wish to learn about the use of computers in health care and health education, consultant to faculty who wish to use the computer in support of their educational efforts, implementer of educational applications for individuals or the institution as a whole, director of implementation teams or units responsible for educational computing support, curriculum designer, or educational researcher. Careers will also exist within credentialing agencies and similar organizations involved in health education. A growing number of positions will also evolve within those areas of private industry that publish or evaluate educational computing materials and develop computing systems to support other aspects of the health education process.

3.5.3 The Health Educational Computing Model Curriculum

3.5.3.1 General Requirements

The health educational computing specialty requires completion of the following:

a) The core curriculum.
b) 35 credit hours of specialty-track course work. The specialty courses have been developed to reflect the students' need for in-depth knowledge in health sciences, computer science, education, and integration of the three disciplines. The courses are listed in Table 3-7, and the course descriptions are given below. The course sequencing is shown in Figure 3-3.
c) 15 credit hours of electives (minimum).
d) The equivalent of a two-quarter practicum.
e) A thesis based on an applied research project of significant scope, equivalent to up to 30 credit hours.

Course No.	Title	Credit Hours
ET1	Learning Theory and Instructional Design in Health Education	3
ET2	Curriculum and Instruction in Health Education	3
ET3	Methods of Evaluation in Health Education	3
ET4	The Health Education System	3
ET5	Computing Systems for Computer-Based Education	5
ET6	CAI Systems	3
ET7	CAI Lesson Development	5
ET8	CMI Systems	3
ET9	Development Techniques for CMI Systems	5
ET10	Issues in Computer-Based Health Education	2

Table 3-7. Health Educational Computing Specialty Track Courses

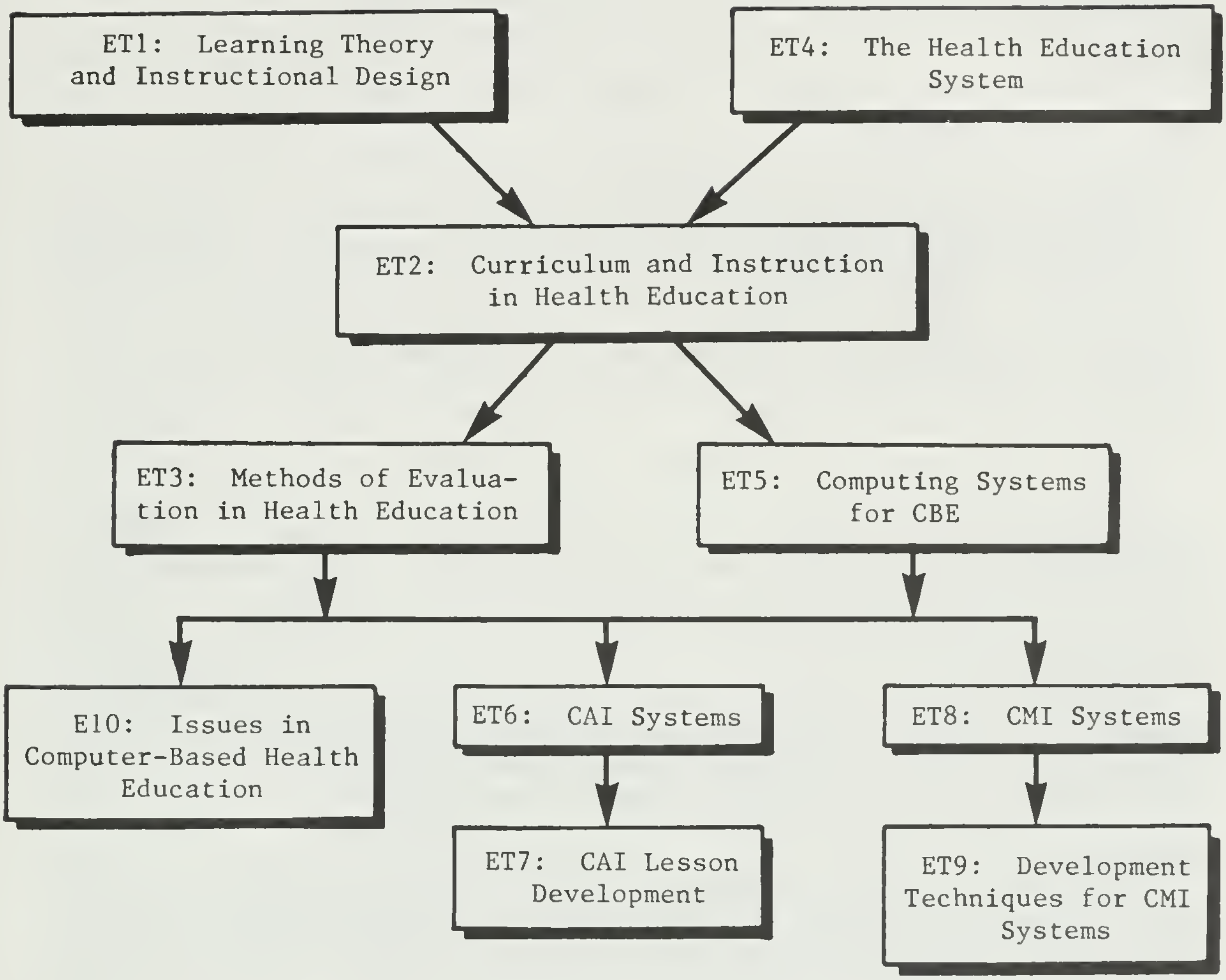

ET1: Learning Theory and Instructional Design
ET4: The Health Education System
ET2: Curriculum and Instruction in Health Education
ET3: Methods of Evaluation in Health Education
ET5: Computing Systems for CBE
E10: Issues in Computer-Based Health Education
ET6: CAI Systems
ET8: CMI Systems
ET7: CAI Lesson Development
ET9: Development Techniques for CMI Systems

Figure 3-3. Health Educational Computing Course Sequence

3.5.3.2 Course descriptions

ET1 LEARNING THEORY AND INSTRUCTIONAL DESIGN IN HEALTH EDUCATION

Prerequisite
None

Objectives
The course teaches the student how to select and employ appropriate learning theories in the design and development of instructional materials. It also teaches techniques for identifying and defining the learning needs and desired outcomes of a selected target population, for identifying possible alternative solutions to meeting these needs, for evaluating the merits of each alternative and recommending one or more

solutions for implementation, and for selecting media appropriate to the implementation, both computer-based and audio-visual.

Approach

Lecture with assigned reading materials and projects in the application of concepts.

Content

Study of modern theories of learning and their relevance to instruction (30%). Application of learning theory to the design of instruction: identification of the target population (10%), determining the learning needs to be met by the instruction (10%), specifying behavioral objectives (10%), determining and organizing content (10%), selecting appropriate instructional strategies and methods of instruction (10%). Evaluating student performance (20%).

ET2 CURRICULUM AND INSTRUCTION IN HEALTH EDUCATION

Prerequisites

Learning Theory and Instructional Design (ET1); The Health Education System (ET4)

Objectives

This course provides an understanding of the curricular processes appropriate to health education and of the relationships among program objectives, content, strategies, teaching methods, and evaluation and their impact on the design and delivery of a curriculum.

Approach

Lecture and selected reading materials and assignments, with a group project to design a curriculum that will meet a health education need. Studies should include analysis of curriculum processes of one or more health education institutions.

Content

The curricular processes of health education (30%). The relationships among program objectives, content, strategies, teaching methods, and evaluation (50%). Their impact on the design and delivery of a curriculum (20%).

ET3 METHODS OF EVALUATION IN HEALTH EDUCATION

Prerequisites

Biomathematics and Biostatistics (I2); Curriculum and Instruction (ET2)

Objectives

This course provides the student with an understanding of the processes and methodology used in the evaluation of curriculum and student performance and of their relation to educational objectives. The student gains experience in the design and use of evaluation tools.

Approach

Lecture with selected readings and assignments and a group project to design, apply, and evaluate different evaluation mechanisms in different health science instructional settings.

Content

A systematic approach to the development of procedures appropriate for the evaluation of curriculum and student performance in the health sciences (20%). Measures of validity and reliability (30%). Related measurement techniques and their utility in different educational settings (50%).

ET4 THE HEALTH EDUCATION SYSTEM

Prerequisite

The Health Care System (C7)

Objectives

There are four primary objectives: (1) To provide the student with an understanding of the organization and structure of the various health education systems; the basic characteristics of these structures, including political, sociological, financial, historical, and psychological; their objectives and unique operational requirements; the categories of students within the health care system, their career objectives and differing knowledge needs; and the relation of health education to health practice and national health needs. (2) To make the student aware of the ethics of health education, legal and ethical requirements for confidentiality and data security, and societal expectations of the health education system, including patient and public health education. (3) To provide the student with an understanding of major issues within the health education system, including competency-based health education, mandatory periodic recertification of health professionals, and credentialing within the health professions. (4) To permit the student to identify current and potential uses of the computer within the health education system and the requirements for successful implementation of such systems.

Approach

Lectures and selected readings.

Content

The American health education system, its goals, objectives, structures, organization, and role in society (50%). Societal and professional expectations (10%). Professional, public, and patient education (15%). Moral, legal, and ethical considerations and mandates (10%). Opportunities for the use of computers within the various components of the health education system (15%).

ET5 COMPUTING SYSTEMS FOR COMPUTER-BASED EDUCATION

Prerequisites

Computer Systems (C3); Evolution and Impact of Computers in Health Care (C8); Curriculum and Instruction in Health Education (ET2)

Objectives

The purpose of the course is to provide an understanding of the requirements and desirable characteristics of computer systems for various facets of computer-based education; an in-depth knowledge of current computer technology, techniques, and modes of delivery used in computer-based education and an assessment of future likelihoods; an in-depth knowledge of the wide variety of input/output devices and peripherals available and becoming available for use in computer-based instruction; an introductory experience in the hands-on use of computer-based education systems, including instructional systems, computer-based testing and grading systems, and educational database systems; an understanding of techniques useful in planning, organizing, managing, and evaluating the performance of computer systems used in computer-based education.

Approach

This course combines the conceptual study of computer systems, languages, and software used in computer-based education with an introductory experience in the hands-on use of such systems. Three lectures each week, with selected readings, are supplemented by 4 hours per week of assignments requiring site visits, demonstrations, and hands-on use of different computer systems used for computer-based education.

Content

Shared systems, networking, dedicated systems, and single-user systems (30%). Plato, Ticcit, and related systems (15%). The role of microcomputers and microcomputer networks in computer-based education (15%). General-purpose languages, special-purpose CAI languages, and generalized software systems for computer-based education (10%). Coursewriter, Tutor, Planit, Pilot, and other specialized languages (10%). Input/output devices and specialized peripherals used in CBE (10%). The videodisk, graphics devices, speech recognition, voice synthesis, and sound reproduction (10%).

ET6 CAI SYSTEMS

Prerequisites

Clinical Decision Making (C6); Computer Science Techniques Used in Health Care I (C9); Methods of Evaluation in Health Education (ET3); Computing Systems for Computer-Based Education (ET5)

Objectives

The course teaches the processes involved in creating, testing, and evaluating the effectiveness of newly developed computer-based instructional materials to meet a defined learning need and develop an understanding of the use of learning theory and principles of instructional design as applied to computer-assisted instruction. The course makes the student aware of sources of CAI materials and teaches processes for evaluating the likely effectiveness of existing instructional materials in meeting a defined learning need. The purposes and functions of the authoring, distribution, and delivery components of a CAI system; desirable characteristics of such systems; and their impact on the transportability and sharing of instructional lessons are taught. The course enables the student to develop an understanding of the integration of computer-based information bases and patient databases into health education.

Approach

Lecture, selected readings and assignments, and hands-on use of existing CAI lessons and materials selected to illustrate various concepts and processes and to provide evaluative experience.

Content

Historical perspective on the use of CAI in health education and the early and current implementers and users of CAI materials in health education (10%). The processes involved in selecting, creating, testing, and evaluating computer-based instructional materials (30%). The appropriate use of computer technology in the instructional process (20%). The role of the authoring, distribution, and delivery components of a CAI system and their impact on lesson transportability and sharing (20%). A survey of current implementers and users of CAI materials in health education and sources of computer-based lesson materials (10%). Identification of research needs and opportunities in computer-assisted instruction (10%).

ET7 CAI LESSON DEVELOPMENT

Prerequisite

CAI Systems (ET6)

Objectives

The course enables the student to become expert in the creation of computer-based instructional materials to meet defined learning needs and in the testing, evaluation, and revision of these materials in accordance with the methodology learned in ET6. In addition, the student should develop the ability to adapt existing computer-based instructional materials to a new environment and design feedback systems for evaluating the effectiveness of these materials in meeting local learning needs.

Approach

This course provides an intensive laboratory experience in the creation of computer-based instructional material of major scope. The material should either be intended to meet an existing educational need of importance or involve exploration of new concepts or approaches to computer-based health instruction. Lecture periods are used for discussion and/or demonstration of specific techniques useful in the laboratory experience.

Content

The application of the principles of instructional design and appropriate computer use in creating computer-based instructional materials (100%).

ET8 CMI SYSTEMS

Prerequisites

Health Information (C5); Computer Science Techniques Used in Health Care II (C10); Methods of Evaluation in Health Education (ET3); Computing Systems for Computer-Based Education (ET5)

Objectives

The course provides an understanding of current and potential uses of the computer in the management of the health education process; develops knowledge about existing computer-based systems for CMI, current users and implementers of such systems, and sources of information about CMI systems suitable for health education; and identifies and defines CMI research problems.

Approach

Lecture and selected readings, with demonstrations and hands-on use of existing CMI applications.

Content

Management of the health education process (15%). Uses of the computer in the management of the health education process (15%). Existing approaches to CMI systems (30%), current implementers and sources of application programs (20%), and future likelihood (10%). Research needs and opportunities in computer-managed instruction (10%).

ET9 DEVELOPMENT TECHNIQUES FOR CMI SYSTEMS

Prerequisite

CMI Systems (ET8)

Objectives

The course helps the student become expert in identifying, defining, and managing the implementation of components of a CMI system and gives experience in the actual implementation of a component of a CMI system.

Approach

This course is an intensive laboratory experience in the design, development, and implementation of components of a CMI system. It might take the form of a group project in the planning and design of a CMI system, with individual development of components of the system. One student might be assigned responsibility for overall project management if it is a sufficiently large system. Lecture periods should be used for discussion and demonstration of methods and techniques useful in the planning, design, and implementation process.

Content

The application of computer technology in the management of the health education process (100%).

ET10 ISSUES IN COMPUTER-BASED HEALTH EDUCATION

Prerequisite

Advanced standing in the health education computing track

Objective

The goal of the course is to make the student aware of issues in computer-based health education, and in health education itself, and of the various points of view about each issue.

Approach

A seminar and discussion series with invited speakers and student presentations.

Content

Seminar topics might include: Confidentiality issues in health education (10%). The changing role of continuing health education (20%). The role of the computer in credentialing and periodic recertification of professional competence (20%). Adaptive testing and competency-based health education (20%). The computer and patient education (20%). Future likelihoods in computer-based health education (10%).

3.5.3.3 Electives

Courses from other specialty tracks in the health computing curriculum are recommended as an alternative to or in addition to advanced studies in education to reflect the student's career choice. A list of the recommended electives in education and in health computing is given in Table 3-8.

3.5.4 An Example Implementation

The final curriculum structure will depend on the resources and goals of each institution, along with each student's career objectives and time available for course work. One sample curriculum plan is shown in Table 3-9. The electives selected will reflect the student's interest in lesson development, administration, teaching, systems design, etc.

The practicum ideally should be interwoven with course work from the time of entry into the specialty. The following principles should be adhered to, if possible:

1. It should start during the first quarter of the specialty track and continue through the last quarter.
2. It should evolve from observation to participation as rapidly as possible.
3. It should give a realistic viewpoint concerning failures as well as successes, the tedium as well as the excitement, the time frames within which things can be accomplished, and projecting time frames.

Approaches that could be used in the practicum include: The mentor system, a long-term one-to-one relationship effective in providing a role model; multiple field experiences; involvement as a member of a team for both short- and long-term projects; work-study experience in units utilizing computer-based education.

Area	Course Title
Health Educational Computing	Administration of Educational Programs (EE1) Educational Psychology (EE2) Educational Research (EE3) Educational Technology (EE4) Program Planning for Continuing Education (EE5) Artificial Intelligence (EE6) Modeling and Simulation (EE7)
Information Systems	Software Design and Development (IT1) Software Project Management (IT2) Database Systems Design (IT3) Computer Architecture and Operating Systems (IT4) Distributed Systems (IT5) Human-Computer Engineering (IT6)
Health Research Computing	Electronics for Biological Scientists (RT1) Digital Computation in Health Science Research (RT5) Stochastic Biologic Processes: I (RE5)
Administration and Management	Hospital Organization and Management (AT1) Economic Analysis of Health Computing Systems (AT2) Legal Environment of Health Care Computing (AT3) Information Analysis and Decision Making Techniques (AT5)

Table 3-8. Health Educational Computing Electives

An applied research or development project of significant scope seems more appropriate for this track than a traditional, basic research thesis because of the integrative nature of the work in which the graduate will be engaged as a practicing professional. The project should deal with a problem of significant scope and complexity. Its purpose should be to serve both as a learning process for the student (including the design and management aspects of such a project) and as a final means for assessing the student's ability to function effectively at a professional level. The project should produce a publishable document as well as a functioning application.

Quarter	Year 1	Year 2	Year 3	Year 4
1	C1 C4 C7 C11	C6 ET3 Practicum	ET9 Elective Practicum	Elective Thesis/ project
2	C2 C8 C12 ET1	C14 ET5 Practicum	ET10 Elective Practicum	Thesis/ project
3	C3 C9 C13 ET4	ET6 Elective Practicum	Elective Practicum	Thesis/ project
4	C5 C10 ET2	ET7 ET8 Practicum	Elective Thesis/ project	

Table 3-9. Example of a Health Educational Computing Curriculum Plan

3.6 HEALTH COMPUTING ADMINISTRATION

3.6.1 The Health Computing Administration Specialist

The integration of information technology into the health care delivery system depends on considerably more than just adaptation of technology to specific instances of health care delivery. It depends on knowledgeable individuals who have the foresight to understand the potential impacts of such systems and incorporate them into the planning phases of many aspects of health care delivery. Further, these individuals must be serving in the health care system at the managerial level so that their contributions to planning efforts will be respected and carried out. Doctoral programs are prescribed for managers in this situation because of the maturity and the extensive and complex background needed in the specialty.

Further, if health care computing is to continue to grow beyond the scope of individual projects, then these same talented people are needed at the policy levels in state and national government and in the national health-related professional societies and nonprofit foundations so crucial to funding projects that lead to major changes in direction for health care.

3.6.2 Careers

Graduates of this program should be qualified to assume a variety of positions including:

Director of computing for a health sciences center
Director of medical computing support groups
Director of medical information systems
Federal government policy-making and/or operations position
Policy analyst in the area of computer technology
Associate director of information systems for clinics and health maintenance organizations
Associate dean or administrative coordinator of computing in medical schools and health sciences training centers
Director of information systems for state, regional, and national registries and projects
Faculty members in programs of hospital and health services administration, health sciences computing, public administration, and administrative sciences
Data system designer and/or director for insurance companies in the health field and for medical products corporations
Leadership role in private nonprofit planning groups
Manager for medical computing firms

3.6.3 The Health Computing Administration Model Curriculum

3.6.3.1 General Requirements

To develop individuals with credibility in the health care and policy-making communities, the health computing administration specialty track was created to add the dimension of management and administrative science to the core disciplines of computer science, health science, and sociology. Upon entry to the program, it is assumed that the student will have had basic exposure to economics, managerial accounting, psychology, and organizational theory and behavior.

The health computing adminstration program requires the student to complete:

a) The core curriculum.
b) 27 credit hours of specialty track course work and 18 hours of electives. The seven required courses developed for the program are listed in Table 3-10, and the course descriptions are given below. The sequencing of these courses is shown in Figure 3-4. These required courses are designed to provide a broad understanding of the scope of the field of health computing administration; the elective courses must be selected to provide depth in the student's preparation for a career.
c) A 3- to 6-month administrative residency, including a 3- to 5-credit-hour seminar. The residency is a key element in the curriculum, since it provides the mechanism to integrate course work and real-world experience.

d) A thesis resulting from in-depth study and analysis of an administrative or management problem. To the extent possible and useful, the thesis research should draw on and work in concert with the residency experience and situation. A maximum of 30 hours of credit for thesis research and writing should be allowed.

Course No.	Title	Credit Hours
AT1	Hospital Organization and Management: Structural and Behavioral Aspects	3
AT2	Economic Analysis of Health Computing Systems	6
AT3	Financial Management of Health Computing Services	6
AT4	Legal Environment of Health Computing	3
AT5	Information Analysis and Decision Making Techniques	3
AT6	Health Information Analysis	3
AT7	Health Care Systems	3

Table 3-10. Health Computing Administration Specialty Track Courses

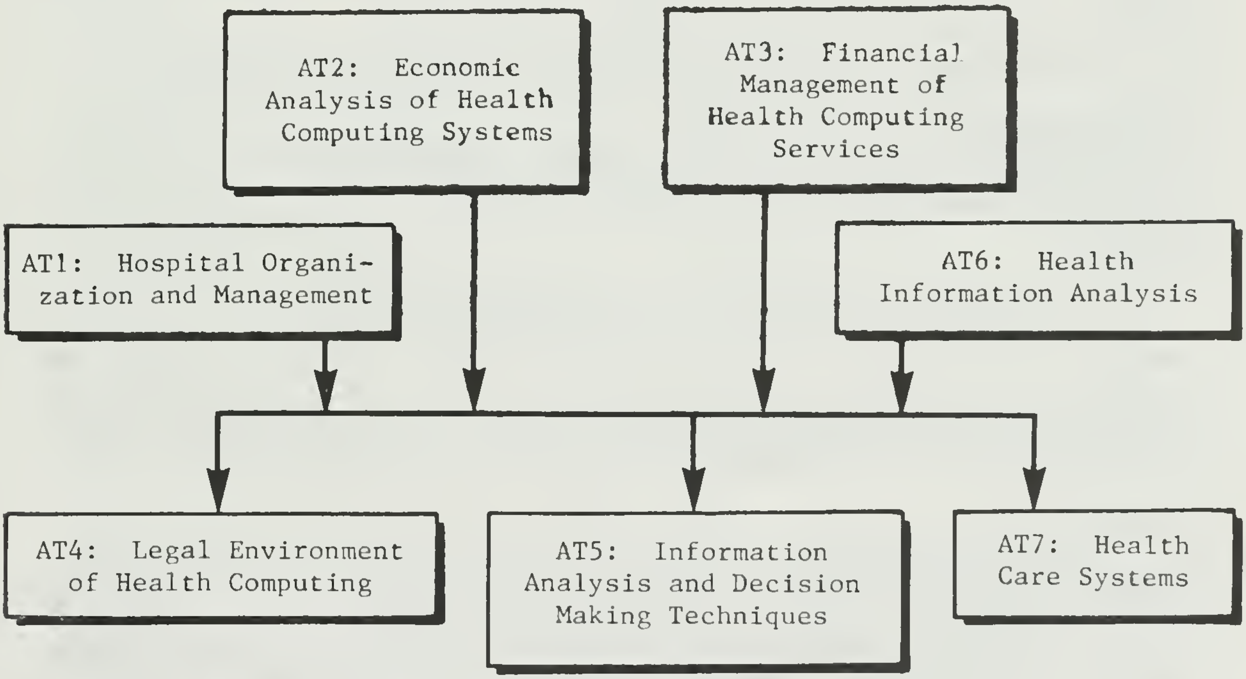

AT2: Economic Analysis of Health Computing Systems
AT3: Financial Management of Health Computing Services
AT1: Hospital Organization and Management
AT6: Health Information Analysis
AT4: Legal Environment of Health Computing
AT5: Information Analysis and Decision Making Techniques
AT7: Health Care Systems

Figure 3-4. Health Computing Administration Course Sequence

3.6.3.2 Course Descriptions

AT1 HOSPITAL ORGANIZATION AND MANAGEMENT: STRUCTURAL AND BEHAVIORAL ASPECTS

Prerequisites

Clinical Decision Making (C6); Evolution and Impact of Computers in

Health Care (C8); Management and Administration of Computers in Health Care (C14)

Objectives

The course presents an analysis of the nature of hospitals as organizations; presents behavioral science concepts and research findings relevant to the management of organizations, especially hospitals and computing organizations; provides insight into the nature of human behavior in organizations as a function of the individual, the groups within which one interacts, and the structure and environment of the larger organization; improves competence in dealing with the complex, unstructured administration situations characteristic of health computing.

Approach

Lectures and discussions of reading materials and selected case studies are used. Selected site visits are recommended.

Content

History, structure, and function of hospitals (20%). Organizational behavior and human performance (25%). The hospital administrator (20%). The computing administrator (15%). The Board of Trustees (10%). The medical and other hospital staff (10%).

AT2 ECONOMIC ANALYSIS OF HEALTH COMPUTING SYSTEMS

Prerequisites

A basic economics course; Evolution and Impact of Computers in Health Care (C8)

Objectives

The purpose of the course is to assist the student in reading and understanding the literature in the economics of the health care delivery system and of computing; increase familiarity with the application of economic analysis in health computing; and reduce the level of economic fallacy in the student's reasoning about health computing issues and problems.

Approach

A lecture and seminar format is used for the three-pronged approach to this course: Study of the economics of health and of the economics of computing to provide the background for study of the economics of health computing. Emphasis is placed on the economics of interfacing health and computing. Modeling techniques should be used to facilitate study. Students select one aspect of economics in health computing to explore in an in-depth issue paper.

Content

Introduction to the economics of health (10%). Economic behavior of hospitals (10%). Economic behavior of health maintenance organizations, community health centers, and other delivery means (10%). Physician's economic behavior (10%). Demand and supply for health and medical services (10%). Introduction to the economics of computing (20%). Demand and supply for computing in health (10%). Insurance and reimbursement (10%). Government provision of services (10%).

AT3 FINANCIAL MANAGEMENT OF HEALTH COMPUTING SERVICES

Prerequisites

An introductory course in managerial accounting; Evaluation and Impact of Computers in Health Care (C8)

Objectives

The course provides an analysis of the financial management of health service and computing organizations by reviewing the current and future sources of financing for both health and computing services and organizations. Methods of operational planning and control (e.g., budgeting and accounting) for health computing services are covered.

Approach

Lectures and reading materials are supplemented by hands-on experience with budgeting and accounting problems.

Content

Financial reporting and operating analysis in the health care industry (10%). Sources of operating revenue, cost reimbursement principles, and alternative reimbursement systems (10%). Capital financing and management (10%). Financing of computer equipment, services, and functions (20%). Contracts negotiation and management and procurement procedures (20%). Operational planning and control (20%). The computer as a tool in financial management and financial management of computing (10%).

AT4 LEGAL ENVIRONMENT OF HEALTH COMPUTING

Prerequisites

Hospital Organization and Management (AT1); Economic Analysis of Health Computing Systems (AT2); Financial Management of Health Computing Services (AT3); Health Care Systems (AT7)

Objectives

The course presents the process and principles of law that apply to health computing and discusses the relevant (both U.S. and non-U.S.) constitutional provisions, statutes, court cases, regulations, and pending case law.

Approach

A lecture/seminar format is used to present the current process and principles. Case law is used extensively to highlight remaining issues. Although emphasis is on the U.S., relevant non-U.S. legislation and rulings are also discussed.

Content

Governmental organization (5%). Process and principles of law (10%). Law specific to the health setting (10%). Licensure of health and computing personnel, hospitals, and other medical care facilities (10%). Defamation, invasion of privacy, and confidentiality (15%). Medical record issues (15%). Copyright, antitrust, and transborder data flow (15%). Computer crime (15%). Other computing issues (5%).

AT5 INFORMATION ANALYSIS AND DECISION MAKING TECHNIQUES

Prerequisites

Hospital Organization and Management (AT1); Economic Analysis of Health Computing Systems (AT2); Financial Management of Health Computing Services (AT3); Health Care Systems (AT7)

Objectives

This course explores the behavior of decision makers as individuals, as members of small groups, and as members of organizations; analyzes information gathering and processing needs for decision making, planning, implementation, and control; reviews approaches and techniques available for evaluating the effectiveness of decision making and information systems for decision making; explores computer -- especially database and communications technology -- as a tool in decision making and analyzing alternatives.

Approach

Lectures and readings are used initially, followed by seminar-discussion format. Case studies should be used for each of three areas -- individual, small group, and organizational decision making. Particularly relevant are cases relying on analysis techniques that use interactive time-sharing models to improve understanding of manager-computer interactions. Expected patterns of behavior and normative models are used for studying the information needs of decision makers and formulating strategies for improving decision making.

Content

Decision theory (15%). Individual, group, and organizational decision making (15%). Operational-, tactical-, and strategic-level information systems (10%). Systems automation questions (10%). Factors in establishing common databases (10%). Data management alternatives (10%). Economic and organizational issues (10%). Decision systems analysis (10%). Evaluation of decision support system effectiveness (10%).

AT6 HEALTH INFORMATION ANALYSIS (Same as IT6)

Prerequisites

Computer Science Techniques Used in Health Care (C9 and C10); Health Information (C5)

Objective

This course provides an in-depth assessment of quality, interpretation, and use of health data, with special emphasis on patient care and quality assurance.

Approach

Students analyze sequentially the data elements used in the health care system for such factors as quality, social and clinical significance, and alternative methods of obtaining information; relative size, volume, and frequency of collection and volatility of data elements; amount and variety of use and interrelationships of data elements; and problems of standardization, aggregation, and release of data. To provide different viewpoints, students' individual or small-group analyses should be compared and discussed. Special attention is given to an assessment of the value of data elements for patient care and other uses. Students should use directed reading, interviews, and observation as the basis for their analyses.

Content

Hospital-generated information: analysis of history, physical, laboratory data, orders, nursing and progress notes, discharge summaries, and nonclinical data (50%). Hospital information flow: quantitative and qualitative assessment of the progressive acquisition and routing of information, with special emphasis on duplication and opportunity for error (15%). Posthospitalization use of information: record abstracting and coding, actual versus possible use in medical audit, quality assurance, research, education, management, accreditation, credentialing, and privacy (15%). Out-patient record: analysis of physician's office versus emergency facility versus clinic information handling, value of information in a time-based versus problem-oriented record, and concept of a single lifetime health record (10%). Alternative approaches: redundancies and deficiencies in current information, benefits and problems of aggregation and brokering of information among institutions in the health care system (10%).

AT7 HEALTH CARE SYSTEMS (Same as IT8)

Prerequisite

Health Information Analysis (AT6)

Objectives

The course reviews the structure and function of the current health care delivery system from the point of view of how information does, or may, flow in the system and influence health care trends. Emphasis is on extra-institutional regional and national information flow; constraints, underutilization, and overutilization of information; multipurpose information; regional and national needs; organization of distribution systems; social implications of general availability of health information.

Approach

Insight into current information flow is obtained by directed reading, field trips, and interviews. Other course concepts are explored through directed reading, group discussion, and individual or small group conceptual design projects.

Content

Medical care: lifetime medical record, PSRO, clinical research, and monitoring for environmental and adverse treatment effects (20%). Regional and national planning: HSAs, CHSS, national health services, and worldwide epidemiologic and other public health uses (25%). Education: undergraduate and postgraduate education; credentialing and relicensure; continuing education and training; and decision aids (10%). Financial: third-party payment; rate setting; Medicare-Medicaid; National Health Insurance; and cost containment (15%). Advanced concepts of information flow for the health care delivery system: institutional reporting interfaces; integrated information flow; regional and state data centers; a national health information system; problems of standardization; social implications; and concepts of data brokering (30%).

3.6.3.3 Electives

In selecting electives, emphasis should be on providing depth in those areas that will best prepare the student for his or her chosen career. Three areas of electives are listed in Table 3-11 - policy, management, and contributing studies. Students interested in health care policy and policy information systems should concentrate their elective choices in the first category, and students who want to become managers should concentrate on studies listed in the second category. The third category provides courses in education and research methodologies as well as additional quantitative course work.

3.6.3.4 The Administrative Residency

To complete the residency a student must spend at least 3 months full time (or equivalent part time) working in computing administration in a health organization. The work should be done under the direction of a preceptor such as a hospital administrator, regional or area health planner, health maintenance organization director, government health official, or medical industry manager directly involved in health computing administration.

The residence experience should be designed in the context of the individual student's need and interest and should not necessarily be limited to areas geographically near the training site.

The overall goal of the residency is to give the student first-hand experience in health computing administration to bridge the gap between theory and practice. Students should be given the opportunity in practice and in seminars to: observe and appraise operating situations and their effectiveness; observe and evaluate leadership styles; evaluate and develop standards of performance and methods for evaluating the organization's ability to meet its goals (or effectiveness in terms of its goals); use methods of problem solving and investigation; and interpret an actual management situation involving computers.

Area	Course Title
Policy	Health Policy
	Public Health Organization and Administration
	Evaluation in Health and Other Social Systems
	Epidemiologic Methods and Public Health
	Economic of Health Manpower
	Planning for Health Organizations
	Long-Term Care and Mental Health Administration
	Health Maintenance Organizations
	Organization and Management of Ambulatory Care Programs
	Program Budgeting and Evaluation
	Elements of Forecasting
	Decision Support Systems (AE1)
Management	Computer Center Management (AE2)
	Network Organization and Management (AE3)
	Software Project Management IT2)
	Managing Conflict in Health Organizations
	Administration of Human Resources
	Management of Hospital Departments
	Hospital Policy and Decision Making (AE4)
	Accounting in Health Care Systems (AE5)
	Management of Training Programs (AE6)
	Operations Research and Principles of Applied Industrial Engineering
Contributing	Software Design and Development (IT1)
	Database Systems Design (IT3)
	Distributed Systems and Data Communications (IT5)
	Quantitative Decision Methods
	Operations Analysis and Modeling
	Experimental Design (RT3)
	Linear Models in Health Science Research (RT4)
	Modeling and Simulation in Health Research (RE6)
	Learning Theory and Instructional Design (ET1)
	Computing Systems for CBE (ET3)
	CAI Systems (ET6)
	CMI Systems (ET8)

Table 3-11. Health Computing Administration Electives

3.6.4 An Example Implementation

The time required to complete the curriculum varies depending on student background, areas of experience, use of summers, sequencing of topics, residency selected, and the nature of the thesis. A sample curriculum implementation is shown in Table 3-12.

	Year			
Quarter	1	2	3	4
1	C1 C4 C7 C12	C11 AT1 AT2	AT5 Residency	Thesis
2	C2 C5 C8 AT3	C13 AT6 Elective	Elective Residency	
3	C3 C6 C9 AT3	AT7 Elective Elective	Thesis	
4	C10 C14 AT2	AT4 Elective Elective	Thesis	

Table 3-12. Example of a Health Computing Administration Curriculum

4 IMPLEMENTATION ISSUES

4.1 GENERAL CONSIDERATIONS

The scope of this curriculum makes it highly improbable, and even undesirable, to think of implementing all aspects initially at a single institution. Practical considerations dictate the selection of a focus, such as all or part of a track, that is compatible with the institution's goals and resources. To illustrate, a health sciences institution with a strong doctoral program in bioengineering might elect to add resources allowing study in the health research computing track. Or a school with a program in health administration might add the health computing administration track to its offerings. At the other end of the spectrum, a computer science department with ties to health computing facilities might grant a doctoral degree in health information systems. As a further example of specialization, a medical school might join with an academic computer science group to offer a joint degree program in clinical decision making, a subset of the health information systems track.

To further illustrate the flexibility of this model curriculum, if the core competencies are met it would be possible to offer a Ph.D. degree, rather than a professional degree, for students who expect to spend their careers doing basic research in the health computing field (as distinct from students who plan to use computers in support of basic health research, as described in the health research computing track).

4.2 SPECIFIC RECOMMENDATIONS

An institution contemplating offering even a part of the curriculum is faced with a number of very practical considerations. Some of these are:

availability and background of faculty
student background and interests
available facilities
organizational home of the program

Each of these issues is discussed in greater detail below, pointing out some of the key problems that must be overcome and providing some general guidelines for implementation.

Faculty

Courses in the health computing curriculum cover a broad range of topics, ranging from clinical medicine to computer science. Accordingly, the program must be able to attract and retain faculty members with a diversity of backgrounds, capable of teaching all of the various courses. Faculty members must also have interdisciplinary interests, to provide a cohesive approach to the material and to encourage the interdisciplinary research projects needed to complement the curriculum.

Based on the number of courses shown for the core curriculum and allowing for areas of specialization and sabbatical leave by faculty, a minimum of five full-time equivalent faculty is required to operate a program. Since the accredited health computing professionals needed to serve as faculty do not exist today, it is recommended that at least one of the faculty members be a physician and at least one be a qualified computer scientist. Attention must also be given to the qualifications of preceptors for student practica. At a minimum, theses individuals must understand and be committed to the concepts of integration of the disciplines of computer science, health sciences, and the sociology of complex organizations.

Special attention must be given to the retention of qualified faculty. Because of the diversity of the faculty and the interdisciplinary nature of the field, it is often difficult to recruit faculty. Furthermore, the publications and the research interests of some of the faculty are likely to fall outside the traditional scope of research interests for members of the faculty in its organizational home (e.g., a computer scientist on the medical school faculty or a physician in a computer science department). Such faculty are normally at a disadvantage with respect to promotion and being granted tenure, and special care must be taken to apply appropriate criteria for the evaluation of such faculty.

Students

Students entering a program in health computing typically will have had little or no prior education in this field. They will be attracted to the field from a diversity of disciplines, ranging from computer science and mathematics to engineering to biology. Students with an extensive computer science background, for example, already may have learned the material in the computer science sequence of the core curriculum, whereas the same sequence of courses will be challenging for students without such preparation. This diversity of backgrounds requires flexibility on the part of the faculty and may make it necessary to teach the same material to students with widely differing backgrounds, or to restrict the type of students who can enter the program. This latter course may be appropriate in certain specialized environments. Another possibility is to exempt students from selected computer science core courses (C1, C2, or C3) or from the Structure and Function of Body Systems course (C4) only, based on an advanced standing examination. All other core courses are mandatory. In any case it is important to remember that the focus should be on the student's final competency, rather than on entry-level qualifications.

As with any new discipline, it is necessary to make potential students aware of career opportunities in health computing and to attract them to the academic program. Students with a practical orientation toward the application of computer science are particularly valuable recruits to this discipline. In particular, the development of sophisticated systems at the heart of medical care, such as for clinical decision making, requires someone with both a medical background and an understanding of health computing. In this case it would be important to attract students with clinical training, ideally possessing an M.D. degree, to this field. The alternative is to provide the clinical training within the curriculum.

The authors advocate stipends as a further means of attracting mature students. This is especially important during the practicum experience.

Facilities

To establish a program an academic unit needs space, computing facilities, suitable library and text materials, an availability of health computing projects on campus and in the local community, and resources for field work, practica, and research. In addition, some tracks require additional learning resources, such as biological science laboratories, computer-assisted instruction modules, and simulation or statistical packages.

The faculty, staff, and students of a health computing program should have easy access to one another and to the resources of a medical environment. The cross-fertilization among disciplines is particularly important, and extensive geographical separation of critical components of the program can be a major detriment to both faculty and students. An opportunity to meet and exchange ideas is critical to the ongoing operation of a health computing program.

Similarly, the available computing facilities can greatly shape the types of research, development, and training that go on within the program. Most health computing applications are heavily dependent on the availability of interactive systems and/or signal processing equipment. The availability of microprocessor equipment, graphics, and random access and mass storage media are all important factors in the design and development of modern health computing systems, depending on the tracks being implemented. Hence availability of such computing facilities is essential to education in health computing. The traditional batch-oriented environment that exists within many institutions is simply inadequate to deal with sophisticated health computing applications and in fact may be considered to be detrimental in many ways to the development of effective educational programs in health computing.

The curriculum demands heavy participation by students in a variety of small, medium, and large projects involving the actual design and development of health computing systems. In addition, students are expected to gain familiarity with existing applications during the initial part of their training. These curriculum goals necessitate the availability, depending on the track, of a critical number of persons interested in the ongoing design, development, and operation of a variety of application systems. Such projects and systems provide a basis for understanding the problems and potential benefits of health computing systems and a suitable environment for student projects. Such a setting gives students the opportunity to gain a better understanding of the use, advantages, and disadvantages of health computing systems and to see more clearly the results of their own design and development efforts within the practicum of the health computing core curriculum.

As with other academic programs, the availability of suitable library facilities plays an important role for student and faculty study and research. A well-stocked library for health computing education consists of texts, reference books, on-line reference services and knowledge bases, and monographs in computer science, medicine, biostatistics and biomathematics, and other fields comprising the profession of health computing. In addition to the six or eight journals dealing explicitly with health computing, the library should subscribe to the major computer science journals, particularly in the software and database management areas, and to leading journals in medicine, and publications relating to health regulation. The development and maintenance of such a library requires a significant initial investment, with a continuing outlay for new books and journals.

Organizational Home

A program in health computing can be organized and run within a number of organizational structures. Some examples are a department or division within a medical school, a specialized program within a computer science department, a program within a public health school or school of public administration, a specialization in a school of business administration, or a program within a college of engineering. It should be recognized that the organizational home of the program will have a strong influence on the emphasis of the health computing program, as noted in Section 4.1 above.

5 THE SHAPE OF THE FUTURE

The Committee members as a group and as individuals intend to continue working to establish health computing as a profession. The diversity of its application and the richness of its potential preclude designation of any one track or career in health computing as being more important and worthy of development than any other. There is ample room for growth and significant impact in careers from every track.

Our major short-term goals for fostering the profession's growth are:

1. Develop a set of annotated references for the courses described in this document.
2. Develop a bibliography of supplemental course materials and a library list.
3. Develop specific course outlines and teaching materials, especially for the core courses.
4. Analyze the current job market for health professionals, as a service to institutions who are deciding on the appropriateness of a focus for their programs.
5. Describe curricula for training the supporting health computing professionals.
6. Seek model implementations of the curriculum.*

We welcome our readers' assistance in any of these areas.

Besides these rather practical matters, we continue to grapple with a number of philosophical issues as well. Of major concern to us is the lack of a unifying peer structure within the health computing community. That is, we are uncertain just who our peers are and how to recognize them. The channels of communication among the diverse groups in health computing are unclear, so the vital synergism fostered by information exchange is not as rich as it should be.

Another issue is the question of the need for licensure of health computing developers and practitioners as applications intrude increasingly into the health of individual people. The possibility of a universally available medical record and the use of microcomputers for home diagnostic testing are two imminent realities that provoke such a consideration. It is often difficult for members of the health team, or commercial developers and vendors, to judge the credentials of health computing specialists. So licensure would help to overcome the lack of trust that has developed among health professionals toward computer scientists and suppliers.

---

* A demonstration project for the Health Computing Administration Track is being designed jointly by the CHCE and the Association for University Programs in Health Administration.

A final issue is that of cost -- the cost of this highly specialized training and the cost of health applications development. Certainly as our developers become more knowledgeable through better training as a whole, development costs will drop too. This should lead to more commercialization of health computing applications as they become profitable. But extensive training of health computing professionals must precede attainment of this state of affairs. Accordingly, we must seek ways to interest potential funding groups in helping our universities establish these urgently needed programs.

REFERENCES

1. Duncan, K.A., and R.H. Austing, "Education and Training for Careers in Health Computing," accepted for presentation at the Third World Conference on Computers and Education, Luzanne, Switzerland, July 1981.

2. Shannon, R.H., and K.A. Duncan, "Why a Curriculum in Health Computing?", Proceedings of the ACM Conference, Washington, D.C., 1978.

3. Duncan, K.A. (Ed.), Proceedings of the SIGBIO Symposium on Health Computing Careers, Dallas, Texas, 1977. ACM, 1981.

4. "Training Program in Health Sciences and Computer Technology," Fact Sheet, National Library of Medicine.

5. Peterson, L.L., and J.S. Reisch, "Update on the Status of Medical Computer Science Programs in the U.S. - 1979," ACM SIGBIO Newsletter, Vol.4, No.3, March 1980, ACM.

6. Duncan, K.A., R.H. Austing, S. Katz, R.E. Pengov, R.E. Pogue, and A.I. Wasserman, "Health Computing: Curriculum for an Emerging Profession," Proceedings of the ACM Conference, Washington, D.C., 1978.

BIOGRAPHIES

Karen A. Duncan is an independent consultant to management on information systems in the health care industry. Her clients are health care providers, commercial firms serving the health care industry, and non-profit health-related agencies and institutions. Dr. Duncan has also served as a member of the technical staff of the MITRE Corporation in McLean, Virginia. Prior to joining MITRE she was a member of the faculty of the Medical University of South Carolina in Charleston in the Department of Biometry, the Department of Family Practice and Instructional Resources, and the College of Dental Medicine, where she was Associate Professor and Director of the Office of Computer Resources. Prior to her graduate work, she worked as a registered Medical Technologist in hospital and research laboratories. Dr. Duncan has worked in health information systems for 14 years, and she is a frequent author and speaker. She received her Ph.D. in Biostatistics from the University of Oklahoma Health Sciences Center.

Richard H. Austing is Associate Professor and Associate Chairman of the Department of Computer Science at the University of Maryland, College Park, where he is responsible for the B.S., M.S., and Ph.D. programs in computer science, among other departmental activities. He has been at the University of Maryland for 16 years and during that time has been involved in the development of curricula in computer science and related areas. Dr. Austing is active in the Association of Computing Machinery (ACM) as past Vice Chairman of the Education Board and in ACM's Special Interest Group in Computer Science Education as a member of the Board of Directors and past Chairman. Recently he chaired the ACM working group that prepared "Curriculum '78: Recommendations for the Undergraduate Program in Computer Science" and, with Joyce C. Little, co-authored the paper "Some Guidelines for the Analysis and Design of a Computerized Utilization Review and Reporting System," which appeared in the August 1977 issue of *Medical Record News.* Dr. Austing holds a Ph.D. in Mathematics from The Catholic University of America.

Sidney Katz is a Congressional Science Fellow, sponsored by the Federation of American Societies for Experimental Biology, in the office of Congressman George E. Brown (D-CA). In that capacity Dr. Katz recently coordinated Congressional hearings on the subject of a national Coordinated Health Information System. Dr. Katz is Professor of Physiology at the Medical University of South Carolina in Charleston. He has been involved in the use of computer technology in health research and education for 12 years. Dr. Katz received his Ph.D. in Physiology from New York University and was a post-doctoral fellow at The Karolinska Institute in Stockholm, Sweden.

Ruann E. Pengov is Product Manager for Hewlett Packard's General System Division in Cupertino, California, where she is responsible for Data Communications and Office Systems Products on the Hewlett Packard 3000 Computer System. Prior to joining Hewlett Packard, Dr. Pengov was Study Director for the Office of Technology Assessment, U.S. Congress, Wahington, D.C. Before that she was Director of Computing Services for

Ohio State University's College of Medicine, where she helped design and implement a graduate training program in biomedical computing and information science and a nationwide network for sharing of health-related computer-based instructional materials. Dr. Pengov holds a Ph.D. in Administrative Sciences from Ohio State University.

Richard E. Pogue is Professor of Health Systems and Information Sciences and Associate Professor of Family Practice at the Medical College of Georgia. He is an active classroom teacher, developing and teaching a variety of computer-related courses for students in the health professions. Dr. Pogue has served as coordinator of the Program in Health Systems and Information Sciences for 8 years and has been involved in the use of computers in the health professions for almost 20 years. In addition, he was responsible for academic computer services within the Division of Systems and Computer Services for 8 years. Active in a number of professional societies, Dr. Pogue is currently President of Health Education Network, Inc., and the use of computers in support of health education is his primary area of interest at this time. He received his Ph.D. in Biostatistics from the University of Minnesota.

Anthony I. Wasserman is Associate Professor of Medical Information Science at the University of California, San Francisco, and lecturer in the Computer Science Division of the Department of Electrical Engineering and Computer Science, University of California, Berkeley. His research interests focus on the User Software Engineering Project, which has the aim of creating a methodology and environment for building interactive information systems. Dr. Wasserman is active in the Association for Computing Machinery and the Institute of Electrical and Electronic Engineers Computer Society. He has edited five books and written over 40 technical papers. Dr. Wasserman received his Ph.D. in Computer Sciences from the University of Wisconsin.

APPENDIX A - CORE CURRICULUM TOPICS

I. COMPUTER SCIENCE

- A. Computer System Organization and Architecture
    - 1. Characteristics of Processors and Input/Output Devices
      data representation, digital logic, machine structure, interrupts, addressing, instructions and their execution, microprocessors/microcomputers, evolution
    - 2. Low-Level Programming
      assembly language, microprogramming
    - 3. Operating Systems
      concurrency, memory management, file systems, protection, reliability
    - 4. Networking and Data Communications
      network structures, multiplexing, packet switching, distributed vs. centralized systems
- B. Information Structures
    - 1. Elementary Data Structures
      vectors, arrays, stacks, queues, linked lists, strings, trees
    - 2. Database Management
      database definition and manipulation, database models
    - 3. Sorting and Searching Techniques
      internal and external sorting, static and dynamic search structures (e.g., AVL trees, B-trees)
    - 4. File Organization and Access Methods
      sequential, direct, indexed access, physical and logical characteristics of storage devices
    - 5. Analysis of Algorithms Operating on Data Structures
      techniques for design and construction of efficient algorithms, computational complexity
- C. Computer Languages
    - 1. High-Level Languages
      syntax, semantics, techniques for definition, programming, and programming methodology
    - 2. Language Design
      user languages, query languages, implementation considerations
    - 3. Language Processors
      interpretation vs. compilation, run time structures, assemblers, compilers
- D. Computer Science Techniques Particularly Applicable to Health Systems
    - 1. Data Acquisition, Analysis, and Reduction
      human-computer interfaces, signal processing, and analysis
    - 2. Artificial Intelligence
      representations of data and knowledge, semantic networks, coding systems, decision support systems, natural language processing
    - 3. Modeling and Simulation
      random number generation, transformations, representation,

approximation techniques, model building, and data encoding

4. Database Design
   conceptual models, internal models, database schema and subschema

II. HEALTH

A. Health Science
   1. Structure and Function of Body Systems
   2. Diagnosis and Treatment of Disease
   3. Public Health
      preventive medicine, epidemiology, public programs, evolution of Public Health
   4. Humanistic Aspects of Health Care
      patient concerns, ethics
B. Health Information
   1. Sources of Health Data
      EKG, lab, history, physical, problems of obtaining data
   2. Quality of Health Data
      error rates, reliability, accuracy, completeness
   3. Representation
      coding and classification of health data, medical records structures
   4. Interpretation and Use
      nonquantified terminology, digitizing
C. Clinical Decision Making
   1. Process
      information discrimination, diagnosis, treatment planning, prognosis
   2. Methods
      probabilistic models, inference, deductive logic
D. Health Care Systems
   1. Current Operation
      service and delivery facilities and structures, manpower, health services and utilization, consumer aspects, research, and education
   2. Health Goals and Theory
      alternative systems of health care, preventive health systems, environmental issues, comprehensive health planning and evaluation, public-private issues
   3. National Health Policy
      current policy, policy formation and implementation, Department of Health and Human Services organization and operation, regional and local implementation mechanisms, administrative law and process (e.g., formation of regulations)
   4. Economic Issues
      supply, demand incentives, third-party payers, federal government role in financing and organization, cost-benefit and cost-effectiveness analysis

III. SYSTEM ANALYSIS, DESIGN, AND DEVELOPMENT

A. Requirements Analysis and System Specification
   system analysis, problem definition, formal and informal specification techniques
B. System Design and Implementation
   modular decomposition of systems, design alternatives and evaluation, design representations, systematic programming, programming standards, testing
C. System Quality Assurance and Review
   performance, correctness, reliability, security, flexibility, fit to requirements, documentation
D. Management Aspects
   budgeting/cost estimates, scheduling, personnel deployment, project review techniques, user interface

IV. INTEGRATION OF COMPUTERS IN HEALTH SYSTEMS

A. Evolution of Health Computing
   1. Education
      CAI, CMI, CAT, continuing medical education
   2. Research
      registries, lab data acquisition, pattern recognition
   3. Patient Care
      health information systems, EKG analysis, clinical laboratory, image processing, process control, patient monitoring, clinical decision making
   4. Administration
      management information systems (MIS); admission, discharge, and transfer (ADT); patient scheduling; performance monitoring; third-party payments; quality assurance
   5. Integrative Applications
      hospital information systems, registries and databases for planning and epidemiological research, regional data centers, policy information systems
B. Computer Science Techniques Used in Health Care
   1. Analog Data Acquisition and Use
      physiological recordings, laboratory and clinical physiological process control, clinical instrumentation, human-computer interface requirements in the health environment, invasiveness, quality control
   2. Artificial Intelligence Techniques
      computer assistance in diagnosis, treatment planning, and prognosis; customized instruction; human-computer dialogue; information acquisition and prompting
   3. Modeling and Simulation of Health Systems
      modeling of biological processes, epidemiological simulations, patient simulations for competency assessment and medical education, organizational and health care systems modeling and simulation
   4. Health Database Design
      file design for health records, acquisition and retrieval

of health records for multiple uses, mechanisms for security, quality assurance

5. Health Data Communications
   information flow requirements for primary, secondary, and tertiary care facilities; remote health care; regional, national, and multi-national access to health care data; privacy in interinstitutional communication
6. Health Systems Analysis and Design
   influence of organizational structures and policies, special reliability and criticality requirements, sociology of the health care delivery team and system, potential administrative and educational impact of data availability, cost of data and resource allocation

C. Societal Impact
   1. Societal Issues
      legal considerations, ethics of computers in health care, issues of security, privacy, and confidentiality, effect on the quality of life, depersonalization, double-blind experiments
   2. Technology Assessment
      social structure implications, economic, technical, political, environmental, and social impact

V. SKILLS

A. Management
   1. Management Practice
      planning, organizing, budgeting, controlling, delegating, establishing an environment, evaluating, accounting
   2. Management of Change
      diffusion and communication of innovation, technology transfer, organizational impact, organizational change

B. Research Design
   1. Problem Definition
   2. Experimental Design
   3. Methods of Data Collection and Reduction

C. Educational Methodologies
   1. Instructional Strategies for Health Education
   2. Principles of Learning
      instruction and instructional strategies for program and curriculum development

D. Quantitative Methods
   1. Discrete Mathematics
   2. Calculus
   3. Biomathematics
   4. Biostatistics
   5. Probability Theory
   6. Sampling Theory

E. Qualitative Methods
   1. Communication Skills
   2. Organizational Theory
   3. Individual and Group Behavior

APPENDIX B - CORE CURRICULUM COURSES: APPROACH AND CONTENT

C1 INFORMATION STRUCTURES

PREREQUISITE

One or two years of programming experience in a high-level language; familiarity with assembly language programming concepts.

APPROACH

An understanding of theory, concepts, and techniques for storing and manipulating data is developed. Design, analysis, and implementation of algorithms are stressed. Throughout the course programming projects should be assigned that utilize structured programming techniques (including programming style, good documentation, and testing). A database management system provides the applications environment for topics discussed in the course.

CONTENT

Review (10%) -- Logical and physical representations of vectors, arrays, stacks, queries, linked lists, trees, strings. Algorithms for their implementation.

File Organization and Access (20%) -- Sequential vs. direct access file structures. Physical characteristics of tape, disk/drum, and other bulk storage devices. Concepts of storage and updating of files. Application of data structures to file design. File control systems and utility routines (including input/output specification statements for allocating space and cataloguing files).

Sort/Search Techniques (30%) -- Algorithms for internal and external sorting (including quicksort, heapsort, merge sorting) and searching (including linear, binary, tree, and indexed search). Hashing. Relative performance of algorithms. Implementation of structures and sort/search techniques for multiple-key access.

System Design (40%) -- Integration of data structures, sort/search techniques, file processing methods, and memory allocation into a simple database management system. Concepts of data independence and hierarchical, network, and relational models. Considerations of run time, costs, efficiency, and administration of database. Data reliability and integrity; security and privacy issues.

C2 PROGRAMMING LANGUAGE ORGANIZATION

PREREQUISITE

Information Structures (C1)

APPROACH

Programming languages are specified and analyzed sequentially in terms of their features. Advantages and limitations of these features relative to the run time behavior or programs written in the languages are discussed. Programming assignments should be given for the languages introduced in the course, provided that appropriate compiler/interpreter facilities are available. Examples of languages should be chosen that have application to health computing.

CONTENT

Language Design and Development (40%) -- Formal language concepts, including syntax and characteristics of grammars (e.g., finite state, context free). Definition and structures of a language such as ALGOL 60 or PASCAL. Data types and their constructs. Language features affecting static and dynamic data storage management. Control structures and data transfer constructs, including subroutines, procedures, block structures, and interrupts. Implementation of recursion and decision tables.

Interpretative Languages (25%) -- Compilation versus interpretation. String processing using a language such as SNOBOL 4. Vector processing using a language such as APL.

Run Time Environment (20%) -- Run time checking. Stack organization. Exception handling. Effects of various programming language features on run time environment and binding time.

Lexical Analysis and Parsing (15%) -- Introduction to lexical analysis, including scanning, finite state acceptors, and symbol tables. Parsing techniques.

C3 COMPUTER SYSTEMS

PREREQUISITE

Information Structures (C1)

APPROACH

Concepts are illustrated with examples of operating systems segments implemented on specific computer system architectures. Emphasis is on interdependencies of operating systems and architectures. A laboratory could be included in which students actually implement concepts on a minicomputer or microcomputer. Differences between centralized and distributed systems should be indicated as part of an introduction to distributed systems concepts.

CONTENT

Review (15%) -- Central processor organization. Instruction execution. Memory addressing. Input/output processing.

Architecture (30%) -- Functions of and communication among principal components of a computer system. Hardware implementation of address construction and instruction fetch and execution. Data flow and control block diagrams of a simple processor. Concept of microprogram. Macro implementation. Simple input/output devices and their controllers. Modes of communication with processors.

Operating Systems Concepts (40%) -- Concurrent processes, including problems associated with mutual exclusion, synchronization, and deadlock-processor scheduling. Memory management, including virtual memory, segmentation, dynamic allocation, and protection. Re-entrant programs. Auxiliary memory problems. Recovery procedures. Design methodologies.

Distributed Systems (15%) -- Types of distributed systems. Network protocols. Packet broadcasting. Introduction to telecommunications. User interface considerations.

C4 STRUCTURE AND FUNCTION OF BODY SYSTEMS

PREREQUISITE

Biology

APPROACH

The course presents the basic information concerning the structure and function of the human body, providing a foundation for further study. The method is a combination of a series of lectures, laboratories, and small-group conferences. Extra-classroom study consists of reading assignments, review questions, and other available self-instructional devices including assigned audio-visuals and computer-based aids.

CONTENT

Levels of Organization (20%) -- The chemical basis of life. Molecules and their component parts. The cell as the fundamental unit of life -- its function, organization, reproduction, and growth and development. Cellular metabolism and utilization of food substances. Organization of cells into tissues and the characteristics of these tissues. Integrated and related structures studied as a system.

Support and Movement (20%) -- The bones and their structure and function, with emphasis on their ability to provide support and protection as well as their role in the manufacture of blood cells and storage of inorganic salts. The structure and function of muscles, and their role in moving joints and maintaining posture. Additional aspects of function, include assisting in movement of body fluids, heat production, and maintenance of body temperature.

Integration and Coordination (20%) -- Control and coordination of the various organ systems of the body in the maintenance of homeostasis, e.g., muscle contraction, gland secretion, information processing. Simple (reflex) and complex (integration at higher levels) behavior. Nervous system anatomy. Aspects of somatic and special senses, with regard to control of body functions and maintenance of homeostasis. The major role of the endocrine system in the maintenance of homeostasis. Hormone secretions, their structures of origin and specific functions. Organs concerned with digestion and reproduction.

Processing and Transporting (20%) -- Digestive, respiratory, circulatory, lymphatic, and urinary systems. The process by which material is passed through the digestive tract, as well as interaction with the nervous and endocrine systems. The science of nutrition in terms of carbohydrates, lipids, proteins, vitamins, and minerals and the amounts necessary to maintain health. Respiration and its role in controlling temperature, air purity, speech, smell, and regulation of pH. The circulatory system in health and disease. Transportation by blood of nutrients, hormones, etc. The mechanics, structure, and function of the cardiovascular system. The role of the lymphatic system in maintaining constant tissue fluid volume and defense against disease and infection. The role of the urinary system in carrying away water, salts, and nitrogenous waste material. Regulation of volume of body fluids, red cell production, and blood pressure. Complex mechanisms necessary to maintain water and electrolyte balance as well as acid-base balance necessary for homeostasis.

The Human Life Cycle (20%) -- Reproduction, contraception, and structure and function of the reproductive organs. Genes, chromosomes, and their characteristics, providing a background for understanding the manner in which each individual maintains a unique set of characteristics. Development, growth, and aging.

C5 HEALTH INFORMATION

PREREQUISITE

Structure and Function of Body Systems (C4)

APPROACH

A typical patient's record is followed from the time of hospital admission to completion of the record after discharge, with student participation in or observation of information collection and processing, insofar as possible. The student will use on-site the most common diagnostic tools (e.g., sphygmomanometer, opthalmo-otoscope, and stethoscope) and observe the use of EKG, EEG, clinical laboratory, X ray, and other less commonly used diagnostic equipment. Design includes formal lectures, small group conferences, and field trips.

CONTENT

The Medical Record (20%) -- An overview of the organization and purpose of the medical records. Alternative record systems (e.g, traditional vs. problem oriented). Access to and responsibility for the record.

Obtaining Health Information (60%) -- Tools and methods used to obtain history and physical examination information and laboratory test results (e.g., verbal, observation, chemical analysis, or signal analysis). Related elements of health information such as orders, progress notes, nursing care plans, diagnosis, and prognosis. Reliability of sources of information and quality of data obtained.

Uses of Health Information (20%) -- Differential diagnosis, treatment planning, and prognosis. Care evaluation, utilization review, education, and research. Accreditation, certification, third-party payers, and legal proceedings. Medico-legal aspects. Information retrieval.

C6 CLINICAL DECISION MAKING

PREREQUISITE

Health Information (C5)

APPROACH

Following a review of sources of information used by the physician, a "grand rounds" approach is used to illustrate differential diagnosis and treatment planning for major classes of disease. Students should make extensive use of case studies in related areas to supplement presented cases in order to gain broad exposure to terminology and to reinforce the decision-oriented aspects of the material. This should be accomplished by attending rounds in various departments and using computer simulation of cases.

CONTENT

Review of Available Information (10%) -- The kinds of information most commonly used by physicians in clinical decision making, e.g., history, physical, laboratory tests, clinical signs and symptoms, research findings on alternative therapies.

The Clinical Decision Process for Major Classes of Disease (75%) -- Differential diagnosis and treatment planning for the most common diseases of the major body systems, including psycho-social problems.

Alternative Models for Clinical Decision Making (15%) -- Clinical decision making as an art or science. Physician assistants. Self-care. Computer-aided diagnosis and treatment planning. AI models. Bayesian models.

C7 THE HEALTH CARE DELIVERY SYSTEM

PREREQUISITE

None

APPROACH

The material is presented through readings, lecture, and group discussion. The focus is on a comprehensive description of the current system as an integrated system with multiple components and interrelationships. The policies, trends, and forces that have molded the current system and those that will change the current system are emphasized. The American system is presented from the viewpoint of all participants involved. Where time allows, non-U.S. systems will be presented. Throughout, both structure and process is presented, with emphasis given to the increasingly important role of information and computer technology in the health care system.

CONTENT

Overview of the Health Care System (5%) -- Goals and objectives. Components. Subsystems and definitions. Role of information models and concepts for study of health care organization and process.

Health Care Organizations and Delivery Mechanisms (15%) -- Comprehensive medical centers and hospitals. Community hospitals. Outpatient departments, emergency departments, and services. Group practice clinics. Neighborhood health centers. Surgicenters and free clinics. Private practices (solo). Programs for special groups (migrants, native Americans, children, etc.). Extended care organizations (nursing homes, home care, etc.). Mental health facilities. Public (veterans, military, etc.) and private roles. Interrelationships and interdependencies.

Consumers of Health Care (10%) -- Assessment of needs: concepts for assessment of need, methods of assessment, source of information, status of health and illness indicators, recognition of needs, perceptions and behavior, socioeconomic factors, and health status. Utilization of health care: determinants of use, general patterns, initiation of use and compliance behavior, socioeconomic factors, spatial factors, supply factors, organizational factors, and financial factors.

Providers of Health Care (15%) -- Types of providers: physicians, dentists, nurses, osteopaths, chiropractors, nurse practitioners, allied health professionals, paraprofessionals. Factors to be discussed for each: education (primary and continuing), estimate of need, conversion of needs to services, supply (generally and by specialty areas), distribution, patterns of practice and responsibility, productivity and incentives, credentialing. Support personnel: administrators, educators, planners, clerical, maintenance, etc. Functioning of the health care team. Role conflicts.

Suppliers (5%) -- Drug companies. Equipment manufacturers, software firms, materials suppliers. Industry structure. Supplier innovation. Regulation and monitoring of suppliers.

Financing of Health Care (10%) -- Private financing of health care: health insurance and basic issues in financing health care, population covered by private health insurance, evaluation of health insurance plans, Blue Cross/Blue Shield, commercial insurance, comprehensive prepaid health plans, and health maintenance organizations. Public financing of health care: social insurance concepts and governmental financing, Medicare, Medicaid, National Health Insurance proposals, military, and Veterans Administration.

Regulators of Health Care (10%) -- Federal government: the role and organization of the Department of Health and Human Services. State and local regulation. Accreditation and certification. Statutes and legal authority. Regulations and the process of their creation. Implementation and effect.

Evaluation of Health Care Systems (10%) -- Measurement and indicators of the quality of health care. Process versus structure versus outcome measures. Provider evaluations. Consumer evaluations. Professional standards review organizations. Other utilization review programs. The role of information systems. Existing evaluative information systems. Technology assessment.

Planning, Prevention, and Research (5%) -- Preventive medicine. Epidemiology. Environmental health. Comprehensive health planning. Medical and health care research. Databases and tools.

Costs, Expenditures, and Cost Containment (5%) -- Costs and the gross national product. Economic costs of disease and injury, expenditures, and price trends. General factors, hospital factors, and physician factors associated with costs. Mechanisms for cost containment: private initiatives, public (governmental) initiatives.

Policies, Forces, and Trends (5%) -- Historical evolution of the public role in health care. An overview of constitutional provisions, laws, court cases, and executive orders. Current issues and policy formation. Current political factors and forces. Broader values, societal forces, and trends. Future policies, forces, and trends. Major conflicts in the American system.

Role of Information (5%) -- Overview and discussion of the key role of information throughout the health care system. Databases in patient care, teaching, assessment, research, planning, etc. Uses in clinical decision making as a means of integrating and summarizing.

C8 EVOLUTION AND IMPACT OF COMPUTERS IN HEALTH CARE

PREREQUISITES

Structure and Function of Body Systems (C4); The Health Care Delivery System (C7)

APPROACH

Focus is on major segments, or subsystems, of the health care system and on developing an understanding of how computing techniques have been, are being, and may be used. The systems can be studied sequentially. For each segment applications are considered in an evolutionary manner, showing historical development, state of the art, and assessment of future directions. Also, societal issues and impact of the technology are considered for each system. Lectures, directed reading, and field trips are used.

CONTENT

Health Education (15%) -- Computer-assisted instruction. Computer-managed instruction. Computer-assisted testing. Continuing education. In-service education. Automated credentialing. Implications and prospects for health education.

Health Research (15%) -- Applications of analog data acquisition, signal processing and analysis, pattern recognition. Biostatistics and biomathematics. Research databases. Clinical registries. Implications and future prospects.

Administration (10%) -- Management information systems. Admission, discharge, and transfer (ADT). Patient scheduling. Performance monitoring. Third-party payments.

Patient Care (40%) -- Health information systems. EKG analysis. Clinical laboratory. Image processing. Process control. Patient monitoring. Clinical decision making. Multiphasic screening. Quality assurance. Implications and potential for patient care applications.

Integrative Applications (20%) -- Hospital information systems. Registries and databases for planning and epidemiological research. Regional data centers. Policy information systems. Medical knowledge databases. Institutional impact, implications and prospects for these areas.

C9 COMPUTER SCIENCE TECHNIQUES USED IN HEALTH CARE I

PREREQUISITES

Information Structures (C1); Evolution and Impact of Computers in Health Care (C8); Systems Analysis, Design, and Development (C13) (pre- or co-requisite)

APPROACH

Approximately one third of the course is spent studying each of three selected computer science areas. For each of the first two areas, one half of the allotted time is spent in lectures on concepts and technical aspects of appropriate techniques. In the third area, the initial lectures focus on aspects of the techniques that are special problems in health care. For all three areas, the other half of the allotted time is spent in one or more field experiences to see the technique used in practice and in seminar discussions of societal issues and technology assessment. Integrative aspects should be discussed. Throughout the course, the instructor should stress that the use of these techniques in health care is evolving, and that the student should consider ways to build on the state of the art presented in this course.

CONTENT

Database Design (30%) -- Database management concepts. File design for health records. Acquistion and retrieval of health records for multiple uses. Interinstitutional databases. Mechanisms for security. Quality assurance.

Data Communication (30%) -- Data Communications concepts. Information flow requirements in primary, secondary, and tertiary care facilities. Remote health care. Regional, national, and multinational access to health care data. Privacy in interinstitutional communications.

Systems Analysis and Design (30%) -- Review of the sociolоty of health care delivery. Influence of organizational structures and policies. Special reliability and criticality requirements. Potential health care system impact of data availability. Cost of data. Resource allocation.

Integrative Aspects (10%) -- Relationship of the use of the techniques to each other. Their role in health computing, in perspective. Likely future utility of these techniques in the health care system.

C10 COMPUTER SCIENCE TECHNIQUES USED IN HEALTH CARE II

PREREQUISITES

Computer Systems (C3); Evolution and Impact of Computer Systems in Health Care (C8); Introduction to Biomathematics and Biostatistics (C12)

APPROACH

Approximately one third of the course is spent studying each of three selected computer science areas. For each area one half of the allotted time is spent in lectures on concepts and technical aspects of the selected technique. Then in each area the lectures are followed by one or more field experiences to see the technique used in practice and by seminar discussions of societal issues and technology assessment. Integrative aspects should be discussed. Throughout the course, the evolving nature of the use of these techniques in health care should be stressed so that the student will consider ways to build on the state of the art presented in this course.

CONTENT

Analog Data Acquisition (30%) -- Analog data acquisition concepts. Physiological recordings. Laboratory and clinical physiological process control. Clinical instrumentation. Human-computer interface requirements in the health environment. Invasiveness. Quality control.

Artificial Intelligence Techniques (30%) -- Artificial intelligence concepts. Computer assistance in diagnosis, treatment planning, and prognosis. Customized instruction. Human-computer dialogue. Information acquisition and prompting.

Modeling and Simulation Techniques (30%) -- Modeling and simulation concepts. Modeling of biological processes. Population models. Epidemiological simulations. Patient simulation for competency assessment and medical education. Organizational and health care system modeling and simulation. Modeling computer capacity, cost-benefit, cost-allocation.

Integrative Aspects (10%) -- Relationship of the use of the techniques to each other. Their role in health computing, in perspective. Likely future utility of these techniques in the health care system.

C11 TECHNICAL COMMUNICATION

PREREQUISITE

None

APPROACH

A seminar format is used to provide both lectures and opportunities for the student to use the communications techniques. Students should draw on their studies in health computing for material to be presented. Each student should have several opportunities to develop an effective writing style by preparing essays, short research reports, and classroom materials. In addition, each student should make at least one informal and one formal presentation involving audio-visual material that the student has developed.

CONTENT

Modes of Communication (5%) -- Oral, written, and graphic communication. Electronic communication. Sources of technical information. Avenues for publication.

Technical Writing (30%) -- Principles of effective writing. Elements of style. Preparation of research papers. Effective use of graphics. Writing speeches. Informal written communications. Business communications.

Oral Communication (30%) -- Speaking patterns and techniques. Formal presentations. Informal speeches. Briefings. Lectures. Audio-visual support. Interpersonal communication. Group interaction. Meeting dynamics.

Effective Lectures (25%) -- Use of goals and objectives. Preparation of study materials. Effective use of supporting media. Testing and feedback. Classroom techniques.

Graphic Techniques (10%) -- Principles of graphic design. Preparation of briefing charts and audio-visual materials. Principles for selection of alternative modes of presentation.

C12 BIOMATHEMATICS AND BIOSTATISTICS

PREREQUISITES

College Algebra; Concepts of Calculus

APPROACH

Mathematical concepts that are important in the application of statistics in biology and medicine are presented first, followed by study of relevant design and analysis techniques. Lectures, illustrations, and assignments are designed to reinforce the student's understanding of the concepts and ability to use the selected techniques appropriately. Analysis of complex designs may be carried out using packaged programs, since the emphasis is on selection of appropriate methods rather than on their execution.

CONTENT

Theory of Statistics (25%) -- Probability theory. Discrete and continuous distributions. Random variables. Populations and sampling.

Linear and nonlinear models. Tests of hypotheses. Statistical inference.

Experimental Design (35%) -- Research design. Sampling and independence of observations. Methods of control. Experimental error and analysis of variance and covariance. Regression. Multivariate analysis. Randomized, block, and factorial designs. Repeated measures. Sequential analysis. Modeling and simulation.

Methods of Data Collection (15%) -- Sampling methods. Sample size. Missing data. Discrete and continuous data collection. Signal analysis. Data transformation and reduction. Random number generation.

Statistical Methods (25%) -- Comparison of means. Analysis of variance. Measures of regression and correlation. Chi-square. Nonparametric methods.

C13 SYSTEMS ANALYSIS, DESIGN, AND DEVELOPMENT

PREREQUISITES

One to two years of programming experience in a high-level language; familiarity with assembly language programming concepts.

APPROACH

Tools and techniques of systems analysis and design are discussed in the context of health computing systems. Emphasis is placed on the process of problem identification and definition, delineation of alternative solutions, selection of best course of action (subject to cost-benefits and effectiveness, as well as other measures), synthesis of the proposed system, and the testing, control, feedback, refining, and optimization of the system. Case studies should be examined to exemplify concepts discussed in lectures.

CONTENT

The Systems Concept (10%) -- Systems life cycle. The organization as a system. Information flow and decision making within organizations. Integration of change and its organizational impact. Concepts of logical and physical models.

Requirements Analysis and System Specification (30%) -- System analysis, problem definition, formal and informal specification techniques.

System Design and Implementation (35%) -- Modular decomposition of systems, design alternatives and evaluation, design representations, systematic programming, programming standards, testing.

System Quality Assurance and Review (15%) -- Performance, correctness, reliability, security, flexibility, fit to requirements, documentation.

Management Aspects (10%) -- Budgeting/cost estimates, scheduling, personnel deployment, project review techniques, user interface, physical security.

C14 MANAGEMENT AND ADMINISTRATION OF COMPUTERS IN HEALTH CARE

PREREQUISITE

Evolution and Impact of Computers in Health Care (C8)

APPROACH

A problem-solving orientation is maintained through independent reading, lecture, and group discussion. Further, each student must participate as a project team member to help develop a paper delineating plans for implementing a computer related project or program in health. Class sessions are designed to enhance the problem-solving skills of team members and to provide the basic theoretical, conceptual, diagnostic, and prescriptive information for use by the interdisciplinary project teams. The last topic of content is designed to parallel and serve student projects.

CONTENT

Management Practice (25%) -- Long-range planning. Implementation strategies. Budgeting. Organization and delegation. Critical path methods for control, monitoring, and evaluation.

Financial (25%) -- Cost estimation. Basic accounting concepts. Cost accounting concepts. Health computing. Cost centers. Financial planning and cost control.

Individual and Group Behavior (10%) -- Interpersonal relationships. Group dynamics. Effect of organization of peer relationships.

Nature of Conflict and Conflict Management (10%) -- Identifying conflict. Role conflict and ambiguity. Clarifying and negotiating role responsibilities. Values and value conflict. Stress and stress management. Impacts of organizational structure on conflict. Managing change in organizations.

Organizational Change (10%) -- Models of change. Communication and diffusion of innovation. Theories of organizational change. The process of change. Change agents. Technological innovation and the organization.

Specific Management and Administrative Topics (20%) -- Management structures in health care delivery, computing organizations, and the health care system. Role of management information systems. Automated tools for project management and control.

Recommendations and Guidelines for an Associate Level Degree Program In Computer Programming

Editors: Joyce Currie Little, Community College of Baltimore
Marjorie Leeson, Delta College
Harice Seeds, Los Angeles City College
John Maniotes, Purdue University Calumet Campus
Richard H. Austing, University of Maryland
Gerald L. Engel, Christopher Newport College

This report presents recommendations and guidelines for a two-year associate degree career program in computer programming. It represents the result of five years of effort by the Association for Computing Machinery's Committee on Curriculum for Community and Junior College Education and is the consensus of a large number of computer educators and industry representatives.

The program is designed to prepare computer personnel for entry-level jobs in applications computer programming. Graduates should be qualified to work on project teams with a systems analyst on projects requiring medium-to-large-scale computer equipment. Specialized options within the program allow a variety of career paths in the computer field.

The report gives the purpose and objectives of the curriculum, a detailed topical outline of recommended subject matter content, and guidelines for local curriculum design. Recommendations are given regarding resources needed for the implementation of the program.

These guidelines are applicable to programs in vocational-technical institutes, community and junior colleges, and colleges and universities interested in the education of computer personnel for computer programming. They may be of use in evaluating existing programs or in establishing new ones.

Key Words and Phrases: associate level programs, career programs, community and junior colleges, computer education, computer programming, computer science education, curriculum, data processing education, education, information systems education, two-year programs, vocational-technical institutes.

CR Categories: 1.52, 2.42, 3.5.

Permission to copy without fee all or part of this material is granted provided that the copies are not made or distributed for direct commercial advantage. The ACM copyright notice and the title of the publication and its date appear, and notice is given that copying is by permission of the Association for Computing Machinery. To copy otherwise, or to republish, requires a fee and/or specific permission. © 1981 ACM.

The current address of Joyce Currie Little is Towson State University, Baltimore, MD 21204.

Contents

Preface

1. Introduction
  - 1.1 Purpose
  - 1.2 Historical Perspective

2. Computer Programming Jobs: Prospects, Skills, and Environments
  - 2.1 Duties of the Computer Programmer
  - 2.2 Job Descriptions
  - 2.3 Job Environment
  - 2.4 Career Paths and Advancement
  - 2.5 Employment Supply and Demand
  - 2.6 Qualities for Success

3. Objectives of the Curriculum
  - 3.1 Purpose of the Curriculum
  - 3.2 Performance Objectives

4. Content of the Curriculum
  - 4.1 Required Computer Content
    - 4.1.1 Principles and Techniques of Programming
    - 4.1.2 Programmer Environment
  - 4.2 Optional Computer Content
  - 4.3 Related Content
  - 4.4 Design Considerations
  - 4.5 Major Programming Language
  - 4.6 Access to Equipment
  - 4.7 Structured Programming

5. Resources for Implementation
  - 5.1 Organizational Matters
  - 5.2 Faculty and Staff
  - 5.3 Equipment and Access
  - 5.4 Instructional Materials
  - 5.5 Adaptation for Continued Relevancy

6. Articulation
  - 6.1 Industry
  - 6.2 Other Educational Institutions
  - 6.3 The Computer Profession

7. Summary

References

Appendices
  - **A. Reference Materials**
    - 1. Computer Programming as a Career
    - 2. Instructional Bibliographies
    - 3. Periodicals and Newsletters
  - **B. Curriculum Implementation Material**
  - **C. Student Activities and Memberships**
  - **D. Source of Job Descriptions**
  - **E. Contributors and Workshop Participants**
  - **F. ACM Committee on Curriculum for Community and Junior College Education, 1981**

Preface

This publication of the Association for Computing Machinery (ACM) represents the first effort of a scientific and technical society to provide curriculum recommendations and guidelines for the education of computer programmers at the associate degree level. Prepared by the ACM Committee on Curriculum for Community and Junior College Education, under the auspices of the Education Board of the ACM, this work was coordinated by the Chair, Joyce Currie Little, Community College of Baltimore, Maryland, with the assistance of Richard H. Austing, University of Maryland, College Park, and Gerald L. Engel, Christopher Newport College, Newport News, Virginia.

The initial meeting of the Committee was held in 1975 with support from the ACM Special Interest Group on Computer Science Education (SIGCSE). Thirteen community and junior college educators established curriculum work as the highest priority with emphasis on the improvement of existing programs to educate computer programmers. Several workshops followed and a draft report resulted which appeared in the SIGCSE *Bulletin* in June 1977. Numerous presentations were given at conferences and revisions of the draft were sent to several hundred interested persons. Reactions were discussed by the Committee for incorporation into the report.

The Committee would like to thank all those who made this report possible. We would especially like to thank Richard H. Austing and Gerald L. Engel for encouragement and support given to the Committee and to this project. Professor Austing was the chairman of SIGCSE and the vice-chairman of the Education Board during most of this time, and Professor Engel was chairman of the Curriculum Committee on Computer Education. Without these two persons, the Committee might not have exlsted. We also thank William F. Atchison, University of Maryland, College Park, who was chairman of the Education Board during most of this work, and David Kniefel, New Jersey Educational Computer Network, who was chairman during its publication. The Committee would like to thank Maureen Shumate for her manuscript review.

The Committee is grateful to all those persons who helped by contributing their comments, reactions, and advice. Many people participated in workshops, reviewed drafts, published announcements, and gave presentations. All those who contributed toward the report are named in Appendix E. Special thanks go to the Virginia Institute for Marine Science, Gloucester Point, Virginia, for hosting several sessions and to the National Technical Institute for the Deaf at Rochester Institute of Technology for assistance with manuscript production.

This work is intended for use by the computer industry, vocational-technical schools and institutes, community and junior colleges, and colleges and universities interested in the education of personnel for computer programming. ACM and the Committee would be pleased to hear your reactions.

1. Introduction

1.1 Purpose

These recommendations are given for a two-year associate degree career program in computer programming. The program is designed to prepare computer personnel for entry-level jobs in applications computer programming. Graduates should be qualified to work on applications project teams with a systems analyst on projects which require medium-to-large-scale computer equipment. The recommendations given should ensure sufficient foundation so that graduates with experience and continued learning may advance in any of a wide variety of career paths appropriate to their own particular interests and abilities.

The report gives the purpose and objectives of the curriculum and provides a detailed topical outline of required core subject matter content. Recommendations are also given for content in other related subjects and in an applied area for specialized applications work. Suggestions for laboratory facilties and staff resources are made. Guidelines for implementation are given to assist an institution in its own curriculum design to meet the needs of local industry. Lists of resource materials are given in the Appendices.

We hope that this report will encourage the reevaluation of existing programs, serve as a guideline in the creation of new programs, stimulate interaction among educational levels and disciplines, and promote improvement of the education of computer programmers.

1.2 Historical Perspective

This is the first set of curriculum recommendations to be produced by a scientific and technical computer society for an associate degree career program in the computer field. It is gratifying to the Committee that ACM has supported this work. It is consistent with ACM's early leadership in establishing curriculum reports at the baccalaureate and graduate levels in both computer science and information systems [6, 8]. These two earlier ACM Curriculum reports published in 1968 and 1973, respectively, credited community and junior colleges with providing education for the applications programmer.

Other curricula guidelines for two-year programs in the data processing area have been prepared at the state and national levels. Under the auspices of the U.S. Department of Health, Education, and Welfare, Office of Education, a business data processing curriculum covering a broad range of jobs was prepared and released in 1963 [28]. In 1964 a companion publication gave suggested techniques for courses of study in vocational and technical programs for electronic data processing in engineering, science, and business [29]. In 1970 a curriculum in scientific data processing technology was released [30], and in 1973 the earlier 1963 report was updated [27]. Work on information processing in scientific work was also done in the early 1960's by the National Science Teachers Association, and a regular newsletter was published [26]. One scientific type curriculum was published by a computer manufacturing company [4]. The national association of two-year colleges, now known as the American Association for Community and Junior Colleges, sponsored a curriculum report published in 1970 [2]. Several state reports have addressed curriculum in the business data processing area, often covering the entire gamut of career opportunities available to two-year graduates [18, 24]. Recent increased emphasis on career education should encourage more awareness of the differing characteristics required for the different types of jobs in this field.

Computer-oriented courses and curricula in community and junior colleges began in the 1950's with a few experimental courses and programs in business and mathematics departments. Local business and industry often provided computer facilities, materials, and instructors for the early programs. Cooperation between schools and industries has existed from the beginning and has been a continuing characteristic of computer-oriented program development in community and junior colleges.

During the early 1960's, the National Defense Education Act provided matching funds for the rental or purchase of computers and other data processing equipment. The colleges used the federal funds provided to acquire small computer systems (e.g., the IBM 1401 and 1620) and unit-record equipment. Data processing curricula in these institutions reflected the type of equipment available.

The 1963 curriculum guidelines in business data processing featured five areas of study: (1) computer data processing basics and equipment, (2) assembler and compiler languages, (3) organization of business, (4) business applications, and (5) supporting sciences and electives. The report's effect on curriculum was extensive and its influence is still apparent in many community and junior college programs. Although these areas are still important in the training of an applications programmer, the content in each area has changed substantially over the years.

In the late 1960's and early 1970's many colleges gradually converted to third-generation computer systems which had auxiliary storage capabilities. The increased capability of the equipment and the increased awareness of its potential for college-wide use led to greater usage of the facility for administrative purposes. A large number of colleges acquired a computer services manager, or director, to serve the entire college community. Often the computer formerly used in a hands-on laboratory environment became physically inaccessible to students. Instead, a closed-shop, scheduled, batch-processing environment was provided. Many colleges acquired terminals to offer students immediate access by timesharing. Others installed remote job entry batch-processing stations serviced by the centralized computer center. A few colleges acquired systems large enough to service their own as well as local high schools' computing needs. Many colleges obtaining a computer for the first time have acquired a minicomputer, often shared with administration. Departments often acquire their own individual microcomputers.

The equipment changes and new technology necessitated adaptation in courses and curricula to incorporate different programming techniques, new data manipulation methods, and a variety of laboratory access methods. New courses were developed and the course content of existing courses modified. Changes came about slowly and were not extensive enough. As a result some curricula still emphasize outdated or inappropriate programming techniques and languages, and sometimes use obsolete equipment.

Since the early 1960's, successive surveys of degree programs in the computer field have been carried out on an national scale by John Hamblen [17]. In the 10-year period between 1966 and 1976, the number of programs at the associate level doubled to reach almost 400, and the number of graduates more than quadrupled to reach slightly more than 6000. Most of the associate level programs in the survey were named data processing and were in a department with the same name. Other programs were in the departments of business or business administration. Associate level programs named computer science or computer programming were few, but increasing in number. Some of the programs named computer science were primarily for transfer students and did not have the training of an applications programmer as a major objective.

The relationship between career and transfer programs is very close and is very complicated. For many years there were few four-year programs available to which students could transfer. By 1976 the number of baccalaureate level programs had grown to almost equal the number at the associate level [17]. As more four-year programs become available, there will be more need for emphasis on transfer programs.

Developments in computers in the 1980's are occurring at an even faster rate than changes occurred a decade ago. Advances in computer technology are having a profound effect on business and industry. Many programmers now have microcomputers available along with timesharing terminals and remote job entry stations. Changes in the way the programmer works will continue [5, 23, 34]. The increased maturity of the field has led to a more standarized vocabulary, better defined job tasks, and a generally accepted body of knowledge and skills required for competence [1, 3, 33]. The disciplined approach to the job, brought about by recent trends in structured programming, will perhaps help bring order to what has been a rather chaotic environment. Studies on productivity and programming practices [40], research on motivation [19], initiation of certification and self-assessment tests, and the development of software engineering [41] all promote a more professional role for the programmer.

2. Computer Programming Jobs: Prospects, Skills, and Environment

There are many kinds of computer programming jobs which require different levels of competency. This section describes the duties and requirements for the application computer programmer. Other more specialized titles are often used, such as business programmer or scientific programmer. Duties and requirements for computer programmers are not necessarily standarized.

Some jobs in computer programming are more advanced and require more education and experience. These include the position of programmer/analyst, which combines the work of the programmer with the work of the systems analyst. Other programmers, called systems programmers, do not perform applications work for an end user but are instead responsible for the systems software, such as the operating system, the programming languages, and the utility packages. Opportunity will most likely exist for programmers to be promoted into these other related areas.

2.1 Duties of the Computer Programmer

A computer programmer assists in the development of automated systems and is responsible for the instructions to the computer. Job tasks include analysis of program specifications provided by an analyst, design of the program logic, coding of the program in the chosen programming language, preparing test data and verifying its accuracy, and providing documentation according to company standards.

A computer programmer who works in the applications area must also understand the problem being solved. For example, programmers working in the business field must have knowledge of the language of business; programmers doing work in an engineering field need to be knowledgeable in the language of engineering. The preparation of a productive applications programmer requires knowledge and awareness of the applications area.

Entry-level computer programmers are usually given an initial in-house training session. This allows the trainee to become familiar with the specific brand of equipment in use, the operating system and utilities, and the differences in the programming languages. It also gives the company a chance to establish its ground rules for computer usage and to ensure that new employees are aware of the data processing standards set by the company. After this session, the trainee is usually assigned as a junior member of a programming team.

Computer programmers at the entry level are often initially assigned to teams for maintenance programming [31]. These programmers analyze existing production programs to isolate problems and to make requested changes. They must use existing documentation, modify the program, expand the existing test data, and retest. In many cases, programmers are assigned to convert these existing programs to more up-to-date programming languages or to convert them to a new system. Programmers must know both the old and new programming languages and the old and new system.

2.2 Job Descriptions

Job descriptions for computer programming personnel are published periodically. Some sources are listed in Appendix D. Several levels of the job are usually specified, ranging from junior to senior. Task analyses of computer programming have led to differentiations among the applications specalities. Most differentiation has been made between the business programmer and the scientific programmer [1]. However, not all programmers fit these two categories. There are many other specialties, many of which do not have a formal job description. For example, a computer programmer might specialize in the development of computer-assisted-instruction software, in computer-aided design, or in library information retrieval systems.

2.3 Job Environment

The environment in which a computer programmer works varies with the applied area, the type of company, the geographic area, and the size of the facility. Applications programmers assigned to teams for work in business are usually a part of a computer center staff, reporting to a team leader, a senior programmer, or a systems analyst. In other cases, a programmer might be a part of a team in the user area. A variety of different team structures could be used [23].

Offices for work are usually similar to most other offices. Some programmers work at their desk with a terminal or a microcomputer. Others submit programs for keypunching and do compilation and testing through a programming coordinator. Still others may use the machines in a hands-on environment for testing. Sometimes programmers take a portable terminal home at night to do extra work. The programmer's work area and the tools needed for use have been referred to as a work bench [7].

Computer programmers must be able to work under pressure. Often they are required to work overtime hours to complete projects by deadline dates. The shortage of personnel has driven salaries to attractive levels [39]. However, turnover of programming personnel is high, presently averaging 25 percent per year [15, 25].

2.4 Career Paths and Advancement

There is ample opportunity for advancement in the computer field. Usually gradual development and maturity proceeds along one of three parallel lines of movement: increasing knowledge of business programming for the applications areas within the company; an increasing interest in the wider perspective of the entire application system; or increasing technical skills. The most typical promotion path for the computer programmer is to the more senior positions, or to programmer/analyst, then to systems analyst. The systems analyst often moves into computer center management. Persons with a more technical orientation tend to go toward systems software programming. Advanced work within the systems programming group can be in areas such as telecommunications or database management systems. Most of these more advanced positions require additional education and experience.

2.5 Employment Supply and Demand

There are not nearly enough personnel trained to work in computer programming. In a survey by National Personnel Associates, out of more than 100 occupations, computer programmers ranked first in demand [11]. The U.S. Department of Labor confirms the serious shortage of personnel, predicting that jobs for computer programmers should increase 102 percent by 1990 [9, 36]. One annual mid-year survey for 1980 shows that, in all data processing, applications programmers rank first in demand, having increased by 33.3 percent in one year [13]. Second in rank were systems software programmers, with 26.7 percent increase. Programmer/analysts were ranked seventh, with 14.1 percent increase.

The personnel shortage is compounded by several factors. Colleges have not been able to graduate nearly enough computer programmers [16]. Although numbers of students increased sharply, associate degree programs graduated only an average of 15 to 18 per program each year over the last 10 years. Some of the graduates were in operations [21]. Teachers have not increased in numbers proportional to the number of students, but have actually decreased [21]. Sufficient new positions for faculty have not been created, due partially to the anticipation of the predicted decline in college age population. Even where positions exist, teachers are leaving them to go into higher paying jobs in industry.

A comparison of national computer personnel production in higher education to industry demand has been given by Hamblen [16]. Need is based on existing jobs as well as on estimates of the number of positions available due to replacement and growth. Production estimates came from data collected with funding from a National Science Foundation grant and from data obtained by the U.S. Office of Education. The 1981 report stated that the two-year colleges are producing slightly more personnel than needed (assumed to be mostly in the operator category), and that four-year colleges are producing far too few. He suggested that the weaker two-year programs should be strengthened and that approximately half of the two-year graduates should plan to transfer to four-year programs. It appears that many two-year colleges have already begun to do that.

In the period from 1971 to 1976, the number of associate degrees granted in computer programming technologies increased 29.6 percent while general data processing technologies decreased 15.1 percent [12]. Industry has accepted the philosophy that a college education should be required for programmers [24], and the two-year colleges have accepted that challenge.

In the midst of these predictions are others which forebode drastic change in the opposite direction. Some say the need for applications programmers will sharply decline [14, 38]. The present applications programmer situation could become somewhat alleviated as more software tools are developed. Custom programming in today's programming languages has become highly labor intensive, and work in the future may be done in other ways. As these changes occur, the demand for programmers will also change. So will their function. Some people feel that the programmer position as we now know it may eventually become obsolete.

Whether or not these predictions come true in the long term, the Committee concludes that the need for applications programmer will exist for some time to come. However, changes in their roles and responsibilities are likely. In particular, there will be an increased interest in productivity, more emphasis on disciplined and structured methods, more in-house training programs, more use of software packages, more use of programming product tools, and more use of contract programmers.

Many associate level graduates continue their college education in related fields of business administration or mathematics and often on a part-time continuing education basis [22]. Some employers, especially those in government service, show a preference for employees with the general cultural level usually associated with the baccalaureate degree, regardless of major field. One recent follow-up study of graduates from a two-year program and a nearby four-year program revealed that both groups had high placement and satisfaction with their education [20]. As more baccalaureate programs in computing are created, it is likely that industry will begin to utilize graduates with majors in computing. More of the associate level graduates will attempt to enter these transfer programs as they progress in their career path in the computer profession.

2.6 Qualities for Success

Community and junior colleges offer open admission education to all those who wish to learn. Some specific curricula, however, such as those with limited space for students, limit enrollments in order to provide adequate education to those who are admitted. In these situations, selection of students is made on this basis of various factors such as academic preparedness for the program, maturity, aptitude tests, or economic need. Admission to computer-related programs has typically been open. Satisfactory completion of a first course serves as a prerequisite to further work. High drop-out rates have resulted due to a lack of awareness about the purpose of the program, insufficient readiness for college, inability in logical thinking, and shortage of patience and persistence in handling details.

It is advisable to counsel entering students so that they are more aware of characteristics needed to be a successful programmer. A brochure on careers is available at a reasonable cost for distribution to prospective students (see Appendix A1). Aptitude tests are available and may be used for counseling. Several authors characterize those who succeed in and enjoy the work of a programmer as usually having good reasoning and logical problem-solving ability and being observant and alert to detail. Programmers also usually enjoy continuing challenges, are able to work under pressure, and are persistent in pursuing a problem to its completion. Efforts to spread career education information should be encouraged so that students may become more aware of job characteristics and requirements in the computer field.

3. Objectives of the Curriculum

3.1 Purpose of the Curriculum

Community and junior colleges often serve as the starting point for the education of many persons who might not otherwise attend a four-year college. Some people use the community college to gain knowledge to change from one career type to another or as a place to update skills. Courses are available full-time or part-time, day or evening, on-campus or off-campus. In most cases, classes are small, facilities excellent and available, and faculty accessible on a personal basis. Students are of all types. By offering courses and curricula in the computer field for all these different types of people, community colleges serve as a viable source of qualified personnel for entry-level computer programming jobs.

The purpose of the curriculum described is to offer students the opportunity to enter the computer programming field as entry-level applications computer programmers. Graduates should be qualified to work on project teams with a systems analyst on applications which require medium-to-large-scale computer equipment. Graduates also should be prepared to work on applications which support the general, administrative, and organizational information processing functions of industry, business, commerce, and government service. Several options within the curriculum allow the selection of specialized areas for more in-depth study, leading to a wide range of potential career paths within the computer field. The curriculum is designed as a two-year associate degree career program for the preparation of graduates for jobs, but it also provides a sufficient foundation as a basis for continued learning in the field.

Computer programming work is found in many different applied areas. Almost every local community will have a need for a business-oriented program. Some communities may need other types as well, such as for scientific work, or in programming for service-oriented institutions, such as hospitals, schools, and churches. Persons already educated in an applied area may wish to do computer programming in that field. Students entering college for the first time should establish an applied area.

The Committee has attempted to work within the mission of the community and junior colleges: to serve community needs. Therefore, instead of prescribing a fixed set of courses, the Committee has specified subject matter topics. Instead of prescribing that all computer programmers be specialists in business work, the Committee has specified that any applied area for which there is a local or a personal need could be combined with core courses. The Committee hopes this approach will provide a flexible framework within which an institution can design and develop its own curriculum to meet the needs of the local community, the variety of aspirations of the students, and the rapidly changing technology with which we work.

3.2 Performance Objectives

The main objective of the curriculum is to produce a graduate who will be able to write application programs. To accomplish the main objective, the graduate must be able to

1. analyze problem specifications prepared by an analyst with respect to the data format, the method of processing, and the required user results;
2. plan detailed program logic; necessary program steps should be defined using a program logic plan or schemata such as flowcharts, decision tables, structured programming charts, or pseudocode;
3. use a problem-oriented procedural language to convert a detailed program logic plan into an efficient and well-structured applications program;
4. modify an existing program or program module to accomplish requested changes in requirements;
5. verify and thoroughly test the accuracy and completeness of computer programs by preparing sample data and by using debugging techniques and software aids;
6. prepare appropriate documentation of computer programs for utilization by the user, production personnel, analysts, or maintenance programmers;
7. use preprogrammed subroutines and utilities, the computer system library, the job control language or system commands, and associated reference manuals and documentation;
8. interpret and use the program specifications and documentation provided by system analysts;
9. illustrate the basic functions of computer hardware at the assembler level by writing assembler language coded programs.

The corollary objective to the main objective, weighing equally with it, is to produce a graduate with the necessary communication skills and related talents who can work in an organization responsibly, effectively, and productively. Toward that end, the graduate must be able to

1. communicate effectively with other programmers and with clerical personnel, analysts, managers, and users using acceptable oral and written English;
2. utilize mathematical and statistical skills to better facilitate problem description, analysis, solution, and digital computation;
3. utilize the standard methods of an organization for information flow through its accounting and information retrieval system;
4. adapt to the pace of constantly changing equipment, high-level programming languages, and programming products; use reference manuals and updates;
5. work effectively as a member of a team in an open, objective manner;
6. be knowledgeable about where, how, and why computers are used to increase awareness of ethical, social, and economic implications of computing.

It is a temptation to do only specific training for industry in specific programming languages or tools. Two-year colleges must not, at the associate degree level, yield to the temptation to train a specialized technician who may be obsolete with the next configuration of computers and unprepared to continue to learn. The associate degree program must provide a foundation of knowledge and skills sufficient to serve as a base for continued learning. The graduate should be able to do a competent job and have potential for growth. The ability to transfer knowledge about a computer system and programming language to a different mode or form will be necessary as technological changes continue over the next decade.

4. Content of the Curriculum

A topical approach was chosen for the definition of subject matter needed for the core requirements of the curriculum. These topics are purposely not structured into one fixed set of courses. Each two-year college offering this program will wish to combine the material into courses specifically designed for its own needs. The structure chosen by the college for implementation will depend on a variety of factors, including type of industry need, type of student clientele and their previous background, degree of expertise of the faculty, degree of cooperation between industry and the college, type of calendar and scheduling used by the college, degree of innovation desired by the faculty/staff implementers and feasible for the institution, and type of upper level programs nearby. Colleges with existing programs may wish to implement changes gradually or very rapidly, depending on resources available. Colleges starting new programs may wish to try totally new nontraditional course structures and scheduling.

The subject matter has been categorized below into required or core computer content, optional computer content, and related content.

4.1 Required Computer Content

The required computer-related content has been identified and classified into two major areas: *principles and techniques of programming,* and *programmer environment.* The first stresses in-depth programming knowledge, techniques, and skills supported by training in problem-solving and logical analysis which facilitate optimum organization of the data and program for computer solution. The second includes fundamental concepts of hardware and software, and organizational, social, psychological, and economic matters which make up the environment of the programmer within the analysis, design, implementation, and operation phases of an applications project.

These two areas should not be construed to be a course structure. Introductory and advanced material on a topic

Table I. Topics in Principles and Techniques of Programming

1. Data Representation, Structure, Storage, and Processing
   a. Characters, fields, records, files
   b. Data representation, coding, and conversion
   c. Input—process—output cycle
   d. Summarizing, selecting, classifying, sequencing methods
   e. Sorting, searching, merging methods
   f. Records and block lengths: fixed and variable, blocked and unblocked
   g. Tables, arrays, stacks, queues, lists, trees
   h. Direct and inverted files; multi-record files
   i. Sequential, indexed-sequential, virtual, and direct access files
   j. Multivolume files and multifile volumes
   k. File activity, volatility, volume
   l. File updating
   m. File maintenance and security
   n. Reorganizing of files: conversion, modification, restructuring
   o. Calculation concerns: truncation, rounding, accuracy, modes, precision

2. Programming Languages and Logic
   a. Problem analysis
   b. Program logic plans: flowcharts, decision tables, structure and hierarchy charts, Nassi-Shneiderman charts, algorithm statements, data-flow diagrams, pseudocode
   c. Data input and output: types and format
   d. Use of structured programming constructs and extensions: linear sequence, IF-THEN-ELSE, DO-WHILE, DO-UNTIL, and CASE
   e. Routines: housekeeping, initialization, end-of-file, end-of-job
   f. Multiple-level control breaks
   g. Use of parameter data, sentinel fields, program indicators
   h. Use of validation and control features: check digits, hash totals, cross totals, batch totals
   i. Use of compound logical functions based on AND, OR, NOT
   j. Test data creation
   k. Debugging methods; traces, snapshots, dumps
   l. Program correctness: logical equivalence, accuracy
   m. Program efficiency, timing, and style
   n. Program documentation: internal and external
   o. Basic and advanced syntax and semantics of, and in-depth practical projects in, a problem-oriented procedural language: data formats, delimiters, statements, precedence rules, sequence of control, subroutines and linkage
   p. Basic syntax and semantics of an assembler level language: instruction format, operand structure, register and storage structure, storage allocation, mnemonic operation codes, labels, symbolic addresses, declaratives, macro instructions, subroutine linkages, address and operation modification, interrupts
   q. Basic syntax and semantics of one additional specialized language
   r. Use of language reference manuals
   s. Anticipation of differences due to implementation

3. Interface with Hardware and Software
   a. Basic computer architecture
   b. Overview of operating systems
   c. Job stream control language and usage
   d. Use of utility programs, text editors, macros, functions
   e. Use programming products which facilitate programming
   f. Program modules: storage and usage
   g. Input—output routines: buffering, paging, overlap, timing
   h. Compilation—linkage—execution considerations
   i. Resources accountability
   j. Use of assembler routines by non assembler languages and compatibility of data formats
   k. Operational implications of program style upon operator
   l. ·Operational implications of program style upon user

is listed only once, although it may be introduced in one course, used in programming exercises, and then covered in more depth in an advanced course. This topical approach is not an ordered teaching outline, but is a list of topics recommended for coverage in a core curriculum.

4.1.1 Principles and Techniques of Programming

The content recommended for a core curriculum, given in Table I, should provide the student with programming techniques, knowledge, and skills for use of the computer as a tool in the performance of practical computer applications. The prospective programmer should be able to analyze programs to determine quality, correctness, appropriateness, and completeness of documentation. The major computer language should be selected on the basis of need in local industry served by the college, and it should be taught in depth. This language should be supplemented by more limited experience with at least one other computer language to allow students to make comparisons between the languages and to give graduates more versatility. The core also includes a foundation in assembler concepts in order to provide a better understanding of hardware/software interaction and compiler-generated code.

Concepts and skills in programming in a procedural language, some foundation in assembler, and exposure to one other language must be combined with the ability to interface the hardware and software by means of an operating system. The ability to access the system library by the job control language or system commands is necessary for use of utility programs and for control of hardware components.

4.1.2 Programmer Environment

The content recommended for knowledge of a programmer's environment is given in Table II. It includes those topics which prepare the programmer to function in the environment of hardware, software, and people. It includes fundamental concepts of computers and peripheral devices, computer languages, and the organizational, procedural, social, psychological, and economic concepts necessary for the day-to-day performance of the programmer. Emphasis should be placed on the role and responsbility of the programmer in the successful analysis, design, implementation, and maintenance of a computer-based information system. This content provides the programmer with an overview of the complete applications project, from source data to distribution of results, and of the role of all personnel involved in the project. It should also include aspects of societal impact, ethics, professionalism, and information

Table 11. Programmer Environment Topics

1. Computer Equipment and Function
    a. Internal functions of central processor unit
    b. Storage devices: primary and secondary
    c. Peripheral devices: data collection, reporting
    d. Computer configurations
    e. Comparisons of hardware components
2. Programming Languages in Organizations
    a. Compilers, interpreters, assemblers
    b. Generators, file management languages
    c. Languages relative to equipment
    d. Languages appropriate to the application
    e. Mode of processing: demand versus batch
3. Computers in Organizations
    a. Evaluation of computers and their usage
    b. Computer center in the overall organization structure
    c. Computer centers: structure, staff, job descriptions
    d. Relationship of programmer to the computer center organization
    e. Statistical data and trends
    f. Costs: hardware, software, other
4. Overview of an Existing Applications System
    a. Necessary reports
    b. Source data
    c. Systems flowcharts
    d. Process flowcharts
    e. Necessary programs
    f. Equipment/configuration needed
    g. Proper documentation for usage of the system
5. Overview of the Systems Cycle and the Programmer's Role in the Project
    a. Analysis phase
    b. Development phase
    c. Implementation phase
    d. Production phase
    e. Evaluation phase
    f. Program maintenance
6. Documentation
    a. Using systems documentation
    b. Using systems flowcharts
    c. Using flow process charts
    d. Evaluation of program documentation
7. Data Elements and Files
    a. Collection, forms, and coding
    b. Mode and format
    c. Data validation and control: mode checking, limit checking, consistency between elements, check digits
    d. File validation and control, internal labels, external labels, file backup, hash totals, batch totals
    e. File structures
    f. File security and techniques
    g. Concern for privacy
8. Report Requirements and Forms Control
    a. Survey of business forms
    b. Input forms: types, evaluation, development, control
    c. Output forms layout
    d. Output forms: distribution and control
    e. Programming considerations dependent upon input and output forms
9. Quality Programming with Structured Approach
    a. Fundamentals of structured analysis and design of programs
    b. Top-Down programming, debugging, testing, implementation
    c. Analysis of a program's structure for improvement: efficiency, style
    d. Review of control structures
    e. Determination of logical equivalence of two differently written programs
    f. Comparison of efficiency of two differently written programs: execution times, storage requirements, programming time, maintenance time
    g. Conversion of unstructured design to structured design
    h. Effect of program languages in structured programming
10. Programming Projects Concepts
    a. Evaluation of programs for good structure
    b. Team approach: design and code walkthrough
    c. Program project coordinator (librarian): function and responsibility
    d. Standards: use of, examples, advantages
    e. Overview of project management methods: personnel assignment activity sheets, Gantt charts, PERT charts
11. The Programming Profession
    a. Career paths
    b. Professional ethics
    c. Licensing and certification considerations
    d. Professional societies
    e. Need for continuing education

concerning potential career options. The student must be made aware of the role and responsibility of the programmer in the organization and in society as a whole.

The content should be taught from the point of view of the programmer. Practical projects should provide the student with an opportunity to analyze prewritten programs, to examine well-written documentation of programs, and to work with well-designed input and output forms. Students should be given poorly designed unstructured programs to convert to structured form. The student should be prepared to work with the tools of, and within the constraints of, the analyst's profession. Use of the traditional documentation forms should therefore be extensive.

Fundamentals of hardware should stress computer equipment and its function, individually and in a configuration. Knowledge of various peripheral equipment—input, output, and storage—should encompass a broad range of systems, from programmable calculators to large-scale configurations. Students should understand the equipment appropriate for a variety of typical applications. Software concepts should expose the student to the variety of software levels and languages and to the purposes of each. Concepts of metalanguages should offer some insight into the structure of languages. This should lead to an awareness of specialized concepts such as data definition languages, report generators, and database management and inquiry systems.

4.2 Optional Computer Content

Some colleges may wish to offer content in addition to the required computer content. Special interests of the student often lead to the selection of additional topics, which can lead to special types of employment or to transfer to four-year programs. Some students may wish to elect a course in numerical methods, while others may wish to learn more about operating systems, data communications, or systems analysis. Optional additional topics recommended for coverage are given in Table III.

Each two-year program should regularly perform an assessment of the needs of local industry. Based on the documentation of such a study, the institution may wish to include additional topics in the core requirements. Colleges serving communities with relatively advanced computer work in high school may choose to design their program to include more advanced courses.

These topics are not intended to reflect courses even though some may warrant a full course. Several of these topics may be combined to form one course. Colleges should have the flexibility to offer topics or programs for the satisfaction of specialized community needs by providing short courses, modules, or community service seminars.

4.3 Related Content

In addition to being skilled technically as a computer programmer, a graduate must be able to use communications and other skills to work in an organization responsibly, effectively, and productively. Subject matter content must therefore include materials to assure proper communication, fundamentals of mathematics and statistics, and knowledge of organizational matters and information flow within a company

English Communications

The importance of speaking, listening, and writing proficiently is increasingly recognized in both academic and professional spheres. Employers have declared that these abilities are as important as specific technical skills [35]. Graduates must work closely with other computer and data processing personnel and must be able to communicate effectively. Written and oral instructions must be both received and given; technical reports and program documentation must be developed, written, and presented. Courses such as English grammer, English writing, technical writing, and speech should be a part of the curriculum.

It is not enough, however, to specify that courses be taken. Computer-related courses should build upon, use, and thereby strengthen these skills. Opportunities to give presentations in class should be found. Verbal instructions must be given to strengthen listening skills. Writing and interpreting narrative instructions should be part of student practice. Oral presentation must be required. Program documentation should be examined and evaluated for correct English as well as for correct form. Students should be expected to use these skills in all classes just as they will be expected to do on the job.

Business Knowledge

The computer programmer working in the computer applications area should be acquainted with certain fundamentals of the business and economic systems, at least as practiced in the local area being served by the college. Knowledge of the functions of a commercial organization and a comfortable use of its vocabulary are important. Skills needed in this area are often met through introductory business or economics courses. Further knowledge of information flow in an organization can be gained from a course in accounting.

Class examples must include applications from the functions of business. Certain typical applications may be chosen for use in laboratory programming exercises. The presentation of each laboratory project should be thorough, so the student will understand both the application and the processing needed.

The programmer is most involved in the implementation phase of the systems cycle and must understand the application being programmed. Information analysis must be performed by the analyst/designer to determine the best way to handle the application. Although the programmer needs an overall perspective of the entire system, more intensive emphasis must be given to the programmer's role in the implementation of the project.

Mathematical Knowledge

The computer programmer has many occasions to use communication skills. Mathematics also serves as a communication language, for one's self and others. Logical thinking and reasoning skills can be improved and organization skills strengthened by using the structure of mathematics. It is therefore recommended that a minimal level of mathematical skills and vocabulary be attained by all those in the program. Students should complete at least one course in finite mathematics, including set theory and logic, probability, permutations and combinations, series and sequences, functions, linear equations, and matrix notation and manipulation. A course in elementary non-calculus-based statistics should provide the necessary logical and vocabulary foundations of statistics. It should include the use of computerized statistical software packages. Students entering the program with a good mathematics background may choose more advanced courses such as advanced algebra, differential and integral calculus, and linear algebra.

Faculty in computer courses have the responsibility of seeing that students apply mathematical knowledge to their computer work. Mathematical vocabulary and usage should be brought into computer programming classes where they apply. The use of Venn diagrams, summation notation, logical tautologies, sums of sequences, and use of terms such as "frequency distribution," etc., should be part of the curriculum. Courses in mathematics, separate from other majors and especially designed to include applications from the computer field, would be helpful for computer programming majors.

Perhaps more than any other area, the mathematics background and expertise of the graduate determines the number of future options available and the variety of directions open as career paths. For example, students expecting to transfer into programs in computer science, engineering, the sciences, or mathematics must necessarily

Table III. Optional Additional Topics

1. Additional Specialized Programming Skills
   a. COBOL, BASIC, FORTRAN, PL/I, Pascal, APL, or other languages not already included in the chosen option
   b. Assembler languages (advanced)
   c. Microprocessor specialized statements
   d. Report program generators (e.g. RPG)
   e. DBMS query languages
   f. Other specialized languages
2. Operating Systems and Job Control
   a. Monitors and executives
   b. Multiprogramming, multiprocessing, and multiaccessing considerations
   c. Virtual storage and paging
   d. New advances in operating systems concept
   e. New advances in data storage
3. Data Communications and Teleprocessing
   a. Overview of data transmission theories
   b. Coding systems and compatibility (ASCII, EBCDIC, etc.)
   c. Overview of error detection and correction
   d. Transmission methods
   e. Transmission equipment (data sets, acoustic couplers, etc.)
   f. Terminals
   g. Computer access and processing
4. Database and Its Management
   a. Concepts
   b. File structures
   c. Data dictionaries
   d. Database management systems concepts
   e. Sources of software
   f. Costs and benefits of software
   g. Administration
   h. Standards for organization use
5. Computer Operations and Operations Management
   a. Operations of peripheral devices (tapes, disks, bursters, etc.)
   b. Console operation
   c. Use of job control language
   d. Job scheduling
   e. Control checks
   f. Dispatching and disbursing
   g. Routine production operations
   h. Record keeping and statistical data
   i. Billing
6. Computer Hardware and Services
   a. Microprocessors and microcomputers
   b. Programmable calculators
   c. Standalone systems
   d. Terminals and leased computer services
   e. Remote job entry stations
   f. Timesharing systems
   g. Service bureaus
7. Applications Software Packages
   a. Sources of packages
   b. Costs of implementation
   c. Evaluation of product
   d. Legal implications
   e. Contracts
8. Systems Analysis for Information Systems
   a. Systems planning
   b. Feasibility studies
   c. Development of a system
   d. Evaluation of a system
9. Systems Design for Information Systems
   a. Specification of logical systems
   b. Suggested implementation into a physical system
   c. Evaluation of design based on user needs

be equipped with mathematical skills generally attained in the traditional course sequence leading up to and through calculus. Students choosing an emphasis in a scientific applied area would also choose the traditional calculus sequence of courses. Those expecting to transfer into business-related fields, however, will usually find that the courses recommended in this report are sufficient for continued study in quantitative methods. Students who plan to transfer should select mathematics courses suitable for their transfer program and institution.

Applied Area of Specialty

Each student anticipating a career in computer programming should choose one applied area of specialty, rather than a series of elementary courses in several fields. Twelve semester credits or more should be taken in an applied area to give the graduate an area of expertise upon which to base computer programming skills. The selection of an applied area may be determined by the institution or may be chosen by the student. In most cases, the selection of the applied area should depend on criteria such as the ultimate goal of the student and job placement priorities. Mature returning students and students who already have a baccalaureate in another field often have an applied area established and need only to complete computer-related courses to obtain employment in the field.

The predominant applications area for computer programmers lies in the supportive functions of business and administration. For that reason, students in the curriculum choosing this area should learn as much as they can about specialized applications—payroll, inventory, financial management, banking, and similar courses. Courses chosen from advanced accounting, personnel management, banking, and marketing could be elected for an applied area specialty.

Another applied area might be mathematics and statistics to support the statistical data gathering, sampling, and the reporting functions of governmental agencies, as well as to support the programming needs of certain research and development agencies. Courses in this case include advanced algebra, differential and integral calculus, linear algebra, and calculus-based statistics.

Many other applied areas could be chosen which lead to productive and interesting careers. The increasing use of computers in such diverse fields as biology, law, chemistry, psychology, the allied health fields, the humanities, and law enforcement offers a large spectrum of opportunities for a challenging profession.

General Education

Most states and institutions require 24 semester credits or the equivalent for general education in each associate level degree program. The requirements are usually chosen by the student from categorical lists of accepted courses. Categories often included are English and the humanities, mathematics and science, and social and behavioral sciences. General education courses in psychology and speech are recommended. The others chosen should contribute to the general cultural level of the student or reflect special areas of interest. Generally, courses in business and computer subjects are not considered general education subjects.

4.4 Design Considerations

Each institution must design its curriculum and the courses within it to fit its own mission and philosophy, the characteristics of its student clientele, the characteristics of its commercial environment, and the other educational opportunities available to students in this field in the community.

Options within the curriculum are possible by means of choices: in the applied area; within the general education category; in the major procedural programming language; and in mathematics. Some institutions may, after study of the community being served, wish to require that this applied area be in a business field. Others may wish to emphasize the scientific programmer option or the health services programmer preparation. Some institutions may instead prefer to advise students concerning job availability in the area and leave the choice of applied area to the student.

The associate degree curriculum should be institutionally designed within the philosophy of the guidelines presented. The program should be at least 60 semester credits, with at least 24 semester credits in computer-related subjects. It should consist of

(1) the required computer topics,
(2) local-option computer topics and electives,
(3) communications, mathematics, and business requirements,
(4) student-option electives for an emphasis in an applied field,
(5) institutional and state general education requirements.

The Committee has encouraged the publication of papers authored by interested community and junior college educators to provide several sample curricula which meet the requirements of this report. Several of these are listed in Appendix B. By examining several different ways to accomplish the educational aims of this report, curriculum planners may be better able to analyze their own situation and to establish a program especially suited to their needs.

4.5 Major Programming Language

Selection of the major programming language will depend on the applied area and on local need. Recent national surveys indicate that the predominant problem-oriented, procedural language for business work is COBOL. Some colleges may find, however, that another language, such as BASIC, FORTRAN, Pascal, or PL/1, is preferred for work in their local community. The major programming language chosen should be justified by documented results of recent surveys of the local area being served.

With the tremendous growth of small computers, an increased need exists for programming with report program generators such as RPG. Likewise, an increased growth in the number of large job shops using some form of database management system (DBMS) has led to an increased use of query languages by users as well as by applications programmers. The question about the appropriateness of a report program generator or a query language to serve as the major language in these recommendations has been a much debated and controversial one. The Committee examined the issue and concluded that although capability in the use of only nonprocedural programming tools might prepare the graduate for specialized technical employment, the graduate's potential career advancement might be limited. It is generally agreed that knowledge of only a nonprocedural language would be less transportable to procedural types of computer programming and that graduates would therefore be less capable of transferring the knowledge of that single programming medium to other languages. The Committee recommends that these specialized application-oriented package systems, such as the report generators and database query languages, be the second language in the program, a local-option requirement, or, in cases where the need is sufficient, the basis for a totally separate program.

The initial exposure to programming need not be in the major programming language. There is much support for the benefit gained when a simple introductory language is used in a timesharing environment or on microcomputers. Many secondary schools now teach BASIC in this manner. This approach has been found to be highly motivational and is relatively successful in exposing students to general programming concepts. With the advent of microcomputers, immediate response demand processing is now feasible and is highly recommended as an initial introduction to programming.

The quality of work of a computer programmer is greatly enhanced by a basic understanding of computer functions at the level of execution of instructions. For this reason, it is recommended that instruction in an assembler language be part of the core. Assembler language could be taught as a separate hands-on programming course in a laboratory setting on whatever machine is available, as a course in elementary computer architecture with assembler programming, or as part of the instruction in the major programming language through the use of compiler-generated code.

4.6 Access to Equipment

Strong arguments have been given for hands-on experience [10]. With availability of computer system access ranging from desk-top computer to network, it is now possible and desirable for students to have experience with different types of computer access. These should include (1) programming for a batch-oriented computer service facility, (2) programming for a timesharing system where each program is entered into the system once, accessed for a debugging session, and then replaced in updated form into the system, (3) programming in an interactive mode, where line-by-line diagnostics are provided and execution-time input of data is in interactive mode, (4) hands-on access to online devices such as card readers and printers to see the relationship of program to job stream set up and to the use and control of forms, and (5) hands-on access to a central processing unit, which provides increased understanding of hardware/software interaction in program loading and execution. Experience with these different types of access need not be threaded throughout the entire curriculum; rather, each course may be designed to include one or more types of access. When not all of these types of access are available on site, special arrangements could be made with industry to provide limited experiences in other access methods.

Instruction in the major programming language requires extensive laboratory practice. The major language programming courses should include a scheduled laboratory period of at least two hours each week. This should be scheduled in one two- or three-hour block of time and should preferably be taught by the class instructor. Scheduled laboratory sessions should be provided with rapid, if not immediate, turnaround during the laboratory class. This is necessary to ensure that during the laboratory class each student be able to obtain experience with the compilation and execution cycle with classmates and instuctor present to discuss and explain situations as they arise. This could be provided by hands-on access to a remote job entry station, with students placing their program decks into the computer input devices, initiating the run, and receiving their results within a very short time on the output printer. It could be attained on terminals by use of a text editor, by use of a computer system with an interactive procedural language, or by direct access to the console of a computer. Additional access should be available during certain other hours of the day so that students may return to work on their programming projects. Should that be impossible, computer service should be scheduled at least three times each day, or continuous service provided with no more than two hours turnaround.

The controlled use of turnaround during the scheduled laboratory allows interaction between the instructor and the student, between the student and the computer, and among students. Such rapid turnaround has in some cases been abused when students eager to get a problem working tend to "change one thing and try it again," without really examining the logic of the program. When laboratories are used properly, groups of 15 to 20 students can have effective interaction with the computer, their instructor, and their classmates.

The interface between the program and the computer system requires that the programmer be able to work with and control the operating system. It is recommended that both instruction in and use of an operating system be required. The student should have experience using program modules and utility program packages and should be able to catalog and recall programs from an on-line library. The student should be made aware of the job accounting systems used for recording time usage, storage usage, and supplies usage for the computer facility.

4.7 Structured Programming

Concepts of structured and disciplined programming should be threaded throughout all programming instruction. Students should be made aware of the basic control structures as they are first encountered and used. They should be taught to read and recognize well-structured programs. They should have experience with the use of structured walkthroughs and should be able to read and evaluate their own programs or programs written by others. Benefit can be gained from requiring written and oral explanation for the rationale behind the decisions made in coding a particular routine. Students should have practice in working alone and also in being a part of a programming team. Class-monitored and instructor-monitored project management of the teams give the student an awareness of scheduling and timing considerations which are needed on the job.

This curriculum content should give the student a good foundation with which to enter the job market. Materials from industry, such as standards manuals, project management techniques, and program logic plan guidelines, would contribute toward making the student aware of the job requirement in that local area. Guest speakers from industry and visits to local industry settings are recommended.

5. Resources for Implementation

Attention must be given to the many problems of implementing and maintaining a computer-related curriculum. Colleges should not attempt to implement a program unless they are fully committed to the necessary investment in time and money to acquire and maintain a competent faculty and up-to-date computer resources. The acquisition of qualified staff and access to appropriate computer equipment and services is critical. The organization and placement of the academic department in relation to other college departments and to the computer facility affects the ease in maintaining the viability of the curriculum. The rapidly changing nature of the topical content, programming languages, and equipment leads to a need for easy adaptability for change. Ways must be found to keep both faculty resources and computer resources up to date.

5.1 Organizational Matters

The need for talented graduates in computer-related occupations continues to increase as computers are more widely used. Courses may be initiated in a number of existing departments, with possible diffusion of effort and undesirable competition among departments. It is recommended that, where possible, one academic department or group be chosen as the host for computer course development to house the faculty and the curricular planning efforts. Where that is not possible, strong emphasis should be given to liaison between departments to allow shared courses, faculty, and equipment.

The relationship between the academic department and its computing facility must be a close one. Although no one organizational structure is being recommended, the structure must supply equipment requirements and access specified. Some colleges could choose to have a chair-director, responsible for both the academic program and the computer services center. Another common structure has an administrative computer services manager at the same organizational level as the academic department chair. Separate facilities, one for the academic department and one for the computer services center, might be considered in some cases. Each community college should analyze its college-wide needs and weigh the several alternatives. No matter which alternative is employed, close communication and mutual respect for interests and needs must be maintained to ensure the cooperation necessary for the viability of the curriculum.

5.2 Faculty and Staff

A substantial portion of the faculty should be maintained in full-time positions to provide coverage of the topics required, especially since part-time day faculty are extremely difficult to find. Qualifications for faculty in the community colleges are generally based on the master's degree as a minimal academic requirement. Graduates from data processing, computer science, or information systems programs are preferred as instructors. Experience in industry as a programmer or analyst is recommended. Graduates from related areas such as business, accounting, economics, engineering, or mathematics are often qualified after several years of work experience in the computer field. People with a degree and recent experience in business data processing are also qualified.

Graduate programs in data processing, computer science, and information systems are producing a very limited number of potential faculty. Community colleges have not been able to compete with what industry and the universities have to offer these graduates: an opportunity to work with up-to-date equipment on interesting new applications for a higher salary. Many faculty now teaching in the programs have degrees in noncomputer-related fields, with training and experience from industry. Many others have come from the ranks of faculty in other related departments, as enrollments in their field decreased, or as their interests in the computer field were aroused. Hence community colleges must currently work for professional development of existing faculty, while also attempting to recruit new teachers from industry and the graduate schools.

Laboratory attendants are often needed, either full time or part time, to work in open laboratory settings to allow students continued access to equipment. With the help of these personnel, valuable equipment can be attended and maintained, supplies can be readily available, and specialized assistance to students can be given. Desirable qualifications for laboratory attendants are an associate degree in the field, an interest in helping students, familiarity with equipment and programming languages, and responsibility toward established duties.

At least one additional person must be responsible for the systems programming effort necessary to maintain the computer system, its operating system, library, programming languages, and software. As updates to programming language packages are received from the manufacturer, they must be inserted into the existing system. This person may be faculty or staff, depending on the organizational structure of the academic department and the computer facility used in the institution. In cases where this person is a teaching faculty member, released time must be provided.

5.3 Equipment and Access

It is vital that a computer resources laboratory be available for class work to be done in this curriculum. There are several ways to supply this laboratory resource, including the use of one or more on-site computers, a computer shared with administration, leased services, or data communications access to a remote computer. Computer usage may also be obtained from local industry or from a neighboring college. Computer resources are available through manufacturers, leasing companies, and computer service centers. A great deal of effort may be needed to determine the most effective and efficient way to provide the computer resources needed for the curriculum and college.

The computer resources laboratory should provide computer service and access and ample data entry key devices for program and data preparation. Space must also be provided for data and program preparation and for checkout. The preparation area should be located near the data entry area and should have work tables. Space must also be provided for computer reference manuals. This area could also serve as a central location for current computer-related periodicals and newspapers.

It is impossible to specify one computer configuration that would be suitable for all two-year programs. A minicomputer may be suitable for one and a medium-scale computer better for another program. A microcomputer laboratory could be used in a network configuration. Department needs are often tied through the equipment administration to those of other departments. When other departments have an extensive use of computer-assisted instruction, sharing resources can present a criticial problem. It is important that the entire college community be aware that, for the curriculum described in this report, the facility is a classroom laboratory. Stated needs and access must not be overrun by well-meant efforts to centralize and economize.

It is difficult to specify needs solely on the basis of total enrollment in the department. A course requiring hands-on access and immediate turnaround may meet within the computer room itself, may use a microcomputer laboratory, or may use a remote job entry station. A course requiring batch-processing will need data entry machines. The quantity depends on the number of students in the course and the programming language being taught. The number of timesharing terminals or microcomputers needed will depend on the number of students in courses requiring their use. The number of hours of computer time needed for runs outside those scheduled for class laboratories will depend on the number of projects assigned in each course and the average number of runs required for each student. Data should be collected for an analysis of computer facility needs.

5.4 Instructional Materials

Many good textbooks are now available. A survey of current books is published annually by the *Computing Newsletter*. A library list of current books has been published jointly by ACM and IEEE (see Appendix A2). Exhibits of current books are held each year at annual conferences of the various computer associations, as well as at the National Computer Conference, sponsored by AFIPS, the Computer Science Conference, sponsored by ACM, and the National Educational Computing Conference. Many sources of material and ideas are available through publications of the professional computer societies and proceedings of their conferences. Content articles in publications of the Data Processing Management Association, the Association for Educational Data Systems, and newsletters of the ACM Special Interest Groups for Business Data Processing, Computer Science Education, and Computer Personnel Research are especially helpful (see Appendix A3).

Laboratory materials are less readily available and are often unsuited to particular equipment and/or courses. Development of laboratory exercises often must be done by the faculty. Development involves a major time commitment on the part of the faculty; this commitment should be recognized by the institution and assigned as a part of the faculty load.

The use of technology as an aid to instruction has been much debated and discussed. Computer-assisted instruction and computer-managed instruction have not been generally available for the teaching of computer-related subjects at the two-year college level. More programmed material is becoming available for use on microcomputers. Some equipment manufacturers provide tutorial packages for programming language instruction with lease or purchase of equipment; these packages should be used where they suit the needs of the curriculum and the equipment being used. Information about progress in this area is available through the ACM Special Group for Computer Uses in Education (SIGCUE) (see Appendix A3).

Many videotape and audio cassette tapes have been produced. Videotape and cassette player/recorders may be used in the classroom and laboratory. Students may replay lessons for individual learning and may watch themselves giving oral presentations. Faculty may use these media to bring in recorded material for in-class activities or may record assignments or solutions to assignments. Videodisk materials will be available soon.

Commercially available film and film strips are becoming more prevalent. Many good films are available, without charge, from equipment manufacturers and university suppliers. A bibliography of films is available (see Appendix A2).

5.5 Adaptation for Continued Relevance

The computing field is one of rapid change. Many of the changes occurring are transparent to the general computer user, but they are a part of the computer professional's livelihood. The half-life of a computer professional (the time it takes the knowledge to decay to a state in which it can provide only half of the facts or techniques to do the job) was estimated in the 1950's to be about ten years, and in the 1960's to be about five years. In 1970 it was estimated to be three years. It is perhaps now even less. Planning is therefore vital to ensure that continual adaptation is as easy to accomplish as possible.

Faculty

The most critical factor contributing to the success of this program is a well qualified and dedicated faculty. It is vital that faculty members participate in workshops with other computer professionals, attend educational conferences, and continue to get experience in industry, either through consulting work, by supervision of field projects of students, through summer employment in industry, or by sabbatical leaves. Faculty should read computer journals and literature in order to keep up with new hardware and software developments. It is essential for faculty to understand the differences in implementations of programming languages on more than one configuration. Their own experience on different equipment allows them to instruct students in such a way that the students are aware of the differences that exist. Faculty should be encouraged to participate in self-assessment procedures and take certification examinations.

Equipment

Community and junior colleges cannot always have the exact version of the hardware configuration that the student is likely to encounter on the job. It is possible, however, to offer the student an acquaintance with each of the types of access to a computer likely to be encountered and to give an exposure to the prevalent configurations of equipment found in the area. College equipment need not be the only computer access nor the only configuration shown to the student.

Field trips to other locations and usage of other computers make it possible for students to be aware of changes in computers and configurations. Colleges with a batch-processing computer and no timesharing capability could consider using the services of a local university, either by telephone or by taking students to the university for their laboratory sessions. Colleges with their own timesharing, but no access to a large batch machine, could arrange for a local company to provide daily service for certain courses.

Microcomputers could be used to allow interactive programming experience. Internships in local industry could provide practical experience with operating computers in a hands-on access manner when not available on-site.

Curriculum

Each college must choose a course structure for its topical content. Progress in educational research may well contribute toward ways to improve course structuring and methods of presentation and instruction. Advisory committees can provide valuable information about community customs and needs. As students complete the program and become employed, they can give invaluable advice concerning what changes in the program may be needed. Continual evaluation of the suitability of the graduates for employment, and examination of their professional success and career development within the industry, must be done.

6. Articulation

6.1 Industry

An important measure of the success of this program is that obtained from job placement records of the graduates. Their ability to get, and to retain, pertinent employment in commerce, industry, and government is one criteria for evaluating the program.

Throughout the history of two-year programs, placement of graduates in computing occupations has been good. In many communities, the community or junior college has been the only source of new computer personnel. Many companies, however, have consistently hired non-computer-educated baccalaureate and master level applicants and provided them with in-house training. In some cases, experience on the specific computer configuration to be used has often been the most important measure for evaluation of applicants. Graduates have in many cases been offered positions a level below their preparation, often at the operator level. Community and junior colleges must recognize that although a strong need for computer programmers exists, and is increasing, the quality of the programs must be maintained and matched to the needs of industry.

Good relations with local industry must be developed. Industry and the institution can both benefit. These relationships can lead to the continuing relevance of the curriculum and to an increasing opportunity for industry—college interaction such as cooperative work—study, internships, or part-time employment for students. These are extremely valuable, but require administrative coordination. Assignments of this nature should be a part of the faculty teaching load. On-the-job experiences are valuable in giving the student early exposure to the job environment and offer an opportunity to make more informed career decisions. Often motivation is increased and a better job placement can be secured upon graduation.

Surveys of the needs of industry in the community being served should be made and viewed in light of the offerings of other neighboring educational programs in an effort to match the educational program to the expected need two years hence. One study done in an effort to determine whether educational offerings were matched to corresponding industry requirements revealed that they were not [32]. Increased interactions with industry are vital both to industry and to the educational institution. It is important for educators to have increased awareness of industry needs and practices and for industry to be aware of the educational offerings in their area. This mutual awareness can lead to more consistent and uniform hiring practices in specific job categories, which should be beneficial to industry and education, employer and employee.

Formal ties between the institution and local industry representatives should be established through curriculum advisory committees. Advisors should meet on a regular basis with college faculty and staff. This regular contact between faculty and advisory committee can be used to ensure continuing appropriateness for local needs. Reports giving advice on how to initiate and use an advisory board are available (see Appendix B).

Department members should maintain direct communication with employers. Too often formal contact with prospective employers is maintained by other offices within the college. Curriculum managers and teachers benefit tangibly by involving themselves in sessions with company representatives. The exchange of information regarding current and future systems, methods, and languages contributes toward interaction and increases the opportunity for placement of graduates. Opportunity for this interaction in a relaxed atmosphere is often possible through local chapters of professional societies such as ACM, ACPA, AEDS, ASM, or DPMA.

Timely feedback from graduates of the program presently employed in industry is also important in keeping the curriculum in line with local needs. Surveys concerned with the preparedness of recent graduates for their employment situation should be done every two years. Follow-up studies on all alumni are useful for tracing the career paths of graduates. Workshops can be offered for alumni to update skills and provide feedback on the program.

Contact should be made with local, state, and federal governments so that faculty become acquainted with the requirements for government programmers. Some of these jobs require entrance tests, experience, and four-year degrees. The present United States government position of computer programmer, for example, ranges from GS-5 through GS-15 and is not open to community college graduates without experience. Faculty and students are advised to obtain the most recent job requirements and descriptions as they are subject to change [37].

6.2 Other Educational Institutions

Secondary Schools.

The number of secondary schools which offer computing is increasing rapidly. A suggested curriculum for grades 9—12 has been published (see Appendix A1). It is important that high school students in computer-oriented programs or courses be made aware of transfer possibilities to two-year colleges. College faculty should maintain close contact with the respective departments at the high school level in order to improve articulation. Secondary school students who complete courses equivalent to the material recommended in this report should be able to obtain advanced placement in the program, early admissions, or have a means of obtaining credit by examination. Courses and programs should be reviewed periodically, in order to keep the high school student informed about the equivalence or nonequivalence of the course content.

Four-Year Programs

The curriculum outlined in this report is designed to be a two-year career program to prepare students for jobs. However, departments which offer this program must articulate with representatives in appropriate departments of nearby baccalaureate degree granting institutions in order to facilitate transfer.

Articulation is complicated because of the varied types of course structures existing in the different educational levels and the variety of departments teaching computer-related courses. A great deal of time can be consumed in this effort. However, the benefits to students and faculty are well worth the effort. Articulation guidelines should be prepared and made available to students entering computer-oriented curricula.

Students who make a decision to transfer should select courses suitable for transfer. Graduates of the program who work for a time and then continue toward a baccalaureate degree may find that additional lower division courses are needed as prerequisites to certain upper division level courses. Students who transfer into computer science programs will need to take the sequence of courses in calculus to prepare for later work. Students who transfer into data processing, information processing, or information systems management may find that most courses taken as part of the recommended program will transfer for credit, but not necessarily as equivalent courses. Some courses may transfer only as lower division electives.

One or more two-year college department members should be assigned to serve in continuing liasion to the transfer institution. They must keep in close contact with the four-year college representative from the appropriate department to facilitate the identification of course equivalences. College-wide liasion resulting in formal transfer agreements has been documented (see Appendix B). Articulation of this kind is an ongoing process and requires an ongoing effort.

Other Two-Year Programs

Although students do not often transfer between community and junior colleges, circumstances sometimes lead students to take one or more courses at a neighboring college. Colleges should cooperate in making this student movement as easy as possible. Regular meetings of faculty from area colleges could facilitate this cooperation and are encouraged.

Accreditation Agencies

Guidelines for use by accreditation agencies could help ensure that technically oriented career programs produce quality graduates. Their recommendations could influence course content and could encourage responsiveness to community needs. The ACM Accreditation Committee has initiated an effort to establish such recommendations for the two-year level. Contact ACM for the status of this work.

6.3 The Computer Profession

Certification examinations in computer programming are now available for the senior level programmer in three specialties: business applications, scientific applications, and systems programming. They are sponsored by eight professional societies through the Institute for Certification of Computer Professionals (ICCP). The senior level of this certification test is beyond the scope of an associate degree graduate without experience. An entry-level examination suitable for the graduates of a program such as that given in this report is in progress. Contact ICCP for more information (see Appendix A1).

Activities to assist students to become familiar with the profession are encouraged. Professional societies can provide sponsorship for student clubs and guest speakers for special activities. Attendance at regional computer exhibits offers an opportunity for professional interactions for students and faculty. Many colleges sponsor computer fairs, often in conjunction with high schools. Local programming competitions can be held each year for students, with winners encouraged to enter regional and national competitions regularly sponsored by ACM (see Appendix C).

7. Summary

This report is the consensus of a large number of educators and industry practicioners. It gives guidelines and recommendations for the design of a curriculum to educate entry-level applications computer programmers. It provides a flexible framework within which a two-year associate level degree career program can be constructed to prepare students for local jobs and at the same time give them a foundation for continued learning.

Rapid changes which affect the work of computer programmers will no doubt continue to occur. It is important that curriculum developers plan for ways to allow for almost continued adaptation. It is also critical that career advisement for this field include information about its dynamic and volatile nature. Those entering this field must expect continual change, continual adaptation, and continual challenges. Those who have talent and enjoy this type of work can expect to find much opportunity for an exicting career.

Many members of the Committee and participants of the workshops have indicated that they have benefited from their involvement with this effort. The Committee, listed in Appendix F, welcomes queries about, and continuing feedback from, these recommendations.

References

1. Berger, R. *Computer Programmer Job Analysis Reference Text.* AFIPS Press, Arlington, Va., 1974.

2. Brightman, R. W. (Ed.) The Computer and the Junior College Curriculum. American Association of Community and Junior Colleges, One DuPont Circle, N.W., Washington, D.C., 1970.

3. The Center for Vocational and Technical Education. *Business Data Processing Occupational Performance Survey.* The Ohio State University, Columbus, Ohio, March 1973.

4. Charp, S. *Scientific Data Processing Courses in Vocational and Secondary Schools.* IBM Data Processing Report E20-0092-0.

5. Cottrell, S., IV, and Fertig, R. T. Applications software trends: evolution or revolution. *Government Data Systems 7,* 1 (Jan./Feb. 1978), 12-13, 26.

6. Couger, J. D. (Ed.) Curriculum recommendations for undergraduate programs in information systems: a report of the ACM Curriculum Committee on Computer Education for Management. *Communications of the ACM 16,* 12 (Dec. 1973), 727-749.

7. Couger, J. D. The programmer's work bench. *Computing Newsletter* (Feb. 1980), 2-3.

8. Curriculum Committee on Computer Science. Curriculum 68: recommendations for academic programs in computer science; a report of the ACM Curriculum Committee on Computer Science. *Communications of the ACM 11,* 3 (March 1968), 151-197.

9. DeCamp, D. Employment: the 1981 outlook. *Computerworld XV,* 1, (Dec. 29/Jan. 5, 1980), 44-48.

10. Desautels, E. J. On computing facilities for computer science. *Computer* (Nov. 1974), 39-48.

11. Dooley, A. Programmers number 1 in employer demand. *Computerworld* (Oct. 6, 1980), 1.

12. Education Division, U.S. Department of Health, Education, and Welfare. *Associate Degrees and other Formal Awards Below the Baccalaureate: Analysis of Six-Year Trends.* U.S. Government Printing Office, Washington, D.C., 1978.

13. Fox-Morris Recruitment Network. *The Fox-Morris Report III,* 3 (1981), 1.

14. Gordon, R. Applications programmers: an endangered species? *Computer Careers News 2,* 5 (April 6, 1981), 1.

15. Half, R. Look (within) before you leap to new job. *Data Management 18,* 5 (May, 1980), 21-23.

16. Hamblen, J. W. *Computer Manpower—Supply and Demand by States.* Information Systems Consultants, R.R. 1, Box 256A, St. James, Mo., 1973, 1975 and 1981.

17. Hamblen, J. W., and Baird, T. B. *Fourth Inventory of Computers in U.S. Higher Education, 1976-77.* EDUCOM, Princeton, N.J., 1979.

18. Korn, W. and Laub, J. *A Suggested Curriculum for the Two-Year Associate Degree Business Data Processing Program.* Wisconsin Board of Vocational Technical and Adult Education, 4802 Sheboygan Avenue, Madison, Wis., 1973.

19. LeDuc, A. L., Jr. Motivation of programmers. *Data Base,* (A Quarterly Publication of SIGBDP), (Summer 1980), 4-12.

20. Lee, A. L., III. *A Followup Study of Computer Science Graduates of East Texas State University and El Centro Community College.* University Microfilms, International, 1977, 77-27, 555.

21. Little, J. C. Computer science-related degree programs at the associate level. In J. Hamblen and C. P. Landis, *The Fourth Inventory of Computers in Higher Education: An Interpretive Report.* EDUCOM and Westview Press, Boulder, Colo., 1980.

22. Little, J. C. Where are our students going? *Proceedings of the June 1973 SIGUCC Symposium.* Association for Computing Machinery, New York, N.Y., 1973.

23. Mantei, M. The effect of programming team structures on programming tasks. *Communications of the ACM 24,* 3 (March 1981), 106-113.

24. Maryland State Department of Education. *Maryland Business Data Processing Advisory Committee Report, 1974.* Maryland State Department of Education, Division of Vocational-Technical Education, P.O. Box 8711, BWI Airport, Baltimore, Md., 1974.

25. McLaughlin, R. A. That old bugaboo, turnover. *Datamation 25,* 11 (Oct. 1979), 96-101.

26. National Science Teacher Association. *PIP Newsletter, An Informational Publication of the Project on Information Processing 1,* 1 (Feb. 1963) 1.

27. Office of Education. *Data Processing Technology—A Suggested Two Year Post High School Curriculum.* U.S. Department of Health, Education, and Welfare, Office of Education, Stock Number 1780-01240, U.S. Government Printing Office, Washington, D.C., 1973.

28. Office of Education. *Electronic Data Processing—I, A Suggested Two Year Post High School Curriculum for Computer Programmers and Business Applications Analysts.* U.S. Department of Health, Education, and Welfare, Office of Education, FS5. 280:80024, U.S. Government Printing Office, Washington, D.C., 1963.

29. Office of Education. *Electronic Data Processing in Engineering, Science and Business.* U.S. Department of Health, Education and Welfare, Office of Education, FS5. 280:80030, U.S. Government Printing Office, Washington, D.C., 1964.

30. Office of Education. *Scientific Data Processing Technology—A Suggested Two Year Post High School Curriculum.* U.S. Department of Health, Education, and Welfare, Office of Education, FS5. 280:80068, U.S. Government Printing Office, Washington, D.C., 1970.

31. Philips, J. W. Entry-level position of computer programmer: a survey. SIGSCE *Bulletin 12,* 1 (Fall, 1980), 198-202.

32. Pollack, M. *An Abstract of Principal Employers' Personnel Requirements and Higher Education Course Offerings in Data Processing.* Bronx Community College, New York, N.Y., 1973.

33. Rohrbach, J. J., Jr. (Ed.) *A Catalog of Performance Objectives, Criterion-Referenced Measures, and Performance Guides for Programming.* Vocational-Technical Educational Consortium of States, Georgia Department of Education, Atlanta, Ga., 1976.

34. Shelly, G. The future: a step forward or a step backward. *Software 1,* 1 (Jan. 1981), 34-38.

35. Taylor C. A. Knowing business and how to communicate best learned skills, study reveals. *Data Management 19,* 6 (June 1981), 34-37.

36. United States Bureau of Labor Statistics. *Occupational Outlook Handbook,* 1979-1980.

37. United States Civil Service Commission. Standards for computer specialist series, GS-334. Standards Division, Washington, D.C., most recent edition.

38. Winkler, C. Martin: applications development without programmers is here. *Computer Career News 2,* 7 (May 4, 1981), 1-4.

39. Withington, F. G. 1980: separating fact from fantasy. *Datamation 26,* 7 (July 1980), 76-82.

40. Yohe, J. M. An overview of programming practices. *Computing Surveys 6,* 4 (Dec. 1974), 221-245.

41. Zelkowitz, M. V. Perspectives on software engineering. *Computing Surveys 10,* 2 (June 1978), 197-216.

Appendices

Appendix A. Reference Materials

1. Computer Programming as a Career

1. American Federation of Information Processing Societies, Inc. A Look into Computer Careers. 1815 North Lynn Street, Arlington, VA 22209, 1980.
2. Association for Computing Machinery. Self-Assessment Procedures. 1133 Avenue of the Americas, New York, NY 10036.
3. Babb, P. A computer career: how to get there from here. *AEDS Monitor 19*, 4-6 (Nov. 1980), 7-23.
4. *Computers and Careers, A Suggested Curriculum for Grade 9-12.* Superintendent of Documents, U.S. Government Printing Office, Washington, DC, Stock Number 1780-1241.
5. Data Processing Management Association. Your Career in Data Processing. 505 Busse Highway, Park Ridge, IL 60068.
6. Griffin, J.P. The job outlook in brief. *Occupational Outlook Quarterly,* U.S. Government Printing Office, Washington, DC 20402 (most recent issue).
7. *Hansen's Weber Salary Survey on Data Processing Positions,* 1080 Green Bay Road, Lake Bluff, IL 60044, latest edition.
8. Institute for the Certification of Computer Professionals (ICCP). The Psychological Corporation. *Report of the 1980 Certificate in Computer Programming Examinations.* 757 Third Avenue, NY 10017, Feb. 1981.
9. Maniotes, J. and Quasney, J.S. *Computer Careers.* Hayden Publishing Company, 1974.
10. McDaniel H. *Careers in Computers and Data Processing.* Petrocelli Books, 1978.
11. Northwest Regional Educational Laboratory. *Elements of Computer Careers.* Prentice-Hall, Inc., 1977.
12. *Occupational Outlook Handbook,* U.S. Department of Labor, Bureau of Statistics, 1980-1981.
13. Stibbens, S. The movement is up, up, and away. *Infosystems* (Dec. 1980), 75-76.
14. Taylor, R.P., and Fisher, J. The relative importance of sources of information for keeping programmers up-to-date. *Proceedings of the Sixteenth Annual Computer Personnel Research Conference, ACM SIGCPR,* Aug. 16-17, 1979, 34-43.
15. Willoughby, T.C. Programmer exemption. *Computer Personnel* (A Quarterly Publication of the SIGCPR) *8*, 2 (March 1980), 10-15.
16. Zalud, B. Ascent of EDP career cliff: dangers, set-backs and rewards. *Data Management* (Sept. 1977), 11-13.

2. Instructional Bibliographies

1. Annual bibliography of computer-oriented books. *Computing Newsletter.* Box 7345, Colorado Springs, CO 80933.
2. Cougar, J.D. Ed. Interesting films to use in dp instruction. *Computing Newsletter XIV,* 9 (May 1981), 6.
3. Lidtke, D. *Computers and Computer Applications: A Film Bibliography.* OCCE Special Report – A Publication of the Curriculum Group of the Oregon Council for Computer Education, 4015 S.W. Canyon Road, Portland, OR 97221, Feb. 1977.
4. Joint Committee of the ACM and IEEE. *A Library List on Undergraduate Computer Science, Computer Engineering, and Information Systems.* IEEE Publication EH0131-3, 1978.

3. Newsletters and Periodicals

1. *AEDS Journal,* Association for Education Data Systems, 1201 Sixteenth Street, N.W., Washington, DC 20036.
2. *Communications of the ACM,* 1133 Avenue of the Americas, New York, NY 10036.
3. *Computer,* IEEE Computer Society, 10662 Los Vaqueras Circle, Los Alamitos, CA 90720.
4. *Computer Decisions,* Hayden Publishing Co., 50 Essex St., Rochelle Park, NJ 07662.
5. *Computer Personnel,* A Quarterly Publication of the SIGCPR, ACM, 1133 Avenue of the Americas, New York, NY 10036.
6. *Computerworld,* 797 Washington Street, Newton, MA 02160.
7. *Computing Reviews,* ACM, 1133 Avenue of the Americas, New York, NY 10036.
8. *Computing Newsletter,* J. Daniel Couger (Ed.), Box 7375, Colorado Springs, CO 80933.
9. *Computing Surveys,* ACM, 1133 Avenue of the Americas, New York, NY 10036.
10. *Data Base.* A Quarterly Newletter of SIGBDP, Special Interest Group for Business Data Processing, ACM, 1133 Avenue of the Americas, New York, NY 10036.
11. *Data Management.* Data Processing Management Association, 505 Busse Highway, Park Ridge, IL 60068.
12. *Datamation,* P.O. Box 200, Greenwich, CT 06830.
13. *DP ED,* North American Publishing Co., 401 North Broad Street, Philadelphia, PA 19108.
14. *EDP Analyzer,* 925 Anza Avenue, Vista, CA 92083.
15. *Government Data Systems,* United Business Publications, Inc., 750 Third Avenue, New York, NY 10017.
16. *Infosystems,* Hitchcock Publishing Company, P.O. Box 3007, Wheaton, IL 60187.
17. *Interface, The Computer Education Quarterly,* Mitchell Publishing Company, 116 Royal Oak, Santa Cruz, CA 95066.
18. Mini-Micro Systems, Cahners Publishing Co., 211 Columbus Ave., Boston, MA 02116.
19. *MIS Quarterly,* 269 19th Avenue South, University of Minnesota, Minneapolis, MN 55455.
20. *SIGCAS Bulletin,* A Quarterly Publication of the Special Interest Group for Computers and Society, ACM, 1133 Avenue of the Americas, New York, NY 10036.
21. *SIGCSE Bulletin,* A Quarterly Publication of the Special Interest Group on Computer Science Education, ACM, 1133 Avenue of the Americas, New York, NY 10036.
22. *SIGCUE Bulletin,* A Publication of the Special Interest Group on Computer Uses in Education, ACM, 1133 Avenue of the Americas, New York, NY 10036.
23. *The Computing Teacher,* International Council for Computers in Education, Eugene, OR 97403.

Appendix B. Curriculum Implementation Material

1. Beil, D. H. The data processing curriculum of the National Technical Institute for the Deaf: a suggested implementation for an AAS degree program in computer programming. *Proceedings of the ACM Annual Conference,* 1978, 812-821.
2. Dillman, R.W., Anderson, W.H, Choper, D.L., Lloyd, J.M., Simms, K.B., and Williams, J.F. Two-year curricula in computer studies – implementing the guidelines. *SIGCSE Bulletin 10,* 3 (Aug. 1978), 140-150.
3. Gorgone, J. T., and Schrage, J. F. A design for the education of computer programmers at the associate level within a baccalaureate level institution. *Proceedings of the ACM Annual Conference,* 1978, 807-811.
4. Lee, I. H., and Plog, C. E. A design for a community junior college curriculum with options for two neighboring institutions. *Proceedings of the ACM Annual Conference,* 1978, 798-806.
5. Illinois Office of Education. *A Guide for Planning, Organizing, and Utilizing Advisory Councils.* Division of Vocational Technical Education, Illinois Office of Education, 100 North First Street, Springfield, Il .

6. Little, J. C. An overview of ACM guidelines and recommendations for a community and junior college career program in computer programming. *Proceedings of the ACM Annual Conference*, 1978, 793-797.
7. Little, J. C. The status of computer education in the community and junior colleges—needs and alternatives. *Proceedings of the National Computer Conference*, AFIPS Press, Arlington, VA, 1978.
8. University of Illinois. A Transfer Handbook for Junior College Students, Academic Advisors, and Counselors. University of Illinois at Urbana-Champaign, Urbana, IL.
9. Maniotes, J. The state of undergraduates computer and data processing programs at public universities in Indiana. *SIGCSE Bulletin 6*, 1 (Feb. 1974), 53-58.

Appendix C. Student Activities and Memberships

1. Association for Computing Machinery, 1133 Avenue of the Americas, New York, NY 10036.
2. Association for Systems Management, 24587 Bagley Road, Cleveland, OH 44138.
3. Data Processing Management Association, 505 Busse Highway, Park Ridge, Il 60068.

Appendix D. Sources of Job Descriptions

1. *Datamation* magazine, Technical Publishing, 666 Fifth Ave., New York, NY 10103.
2. *Infosystems* magazine, Hitchcock Publishing Co., Hitchcock Building, Wheaton, IL 60187.
3. Philip H. Weber Services, A. S. Hansen, Inc., 1080 Green Bay Road, Lake Bluff, IL.
4. *Installation management: Organizing the DP Activity.* IBM Corporation, Dept. 824, Technical Publication/Systems Department, 1133 Westchester Avenue, White Plains, NY 10604.
5. *Occupations in Electronic Computing Systems.* U.S. Department of Labor, Superintendent of Documents, Washington, DC 20402.

Appendix E. Contributors and Workshop Participants

Workshops Participants, August 11-13, 1975, Gloucester Point, Virginia

Richard H. Austing, University of Maryland
Bruce Barnes, National Science Foundation
Frank Cable, Pennsylvania State University
Richard Ciero, Thomas Nelson Community College, Virginia
Richard Dempsey, Pennsylvania State University, Worthington Scranton Campus
John Dineen, Middlesex County College, New Jersey
Gerald L. Engel, Virginia Institute for Marine Science, Virginia
B. Albert Friedman, Sinclair Community College, Ohio
John Gorgone, Purdue University, Indiana University at Fort Wayne, Indiana
Harold Highland, SUNY/Farmingdale, New York
Ron Lenhart, Yavapai College, Arizona
Joyce Currie Little, Community College of Baltimore, Maryland
John Maniotes, Purdue University, Calumet Campus, Indiana
Morris Pollack, Bronx Community College, New York
Richard Reynolds, Orange Coast College, California
Harice Seeds, Los Angeles City College, California

Workshop Participants, May 27-28, 1976, Gloucester Point, Virginia

Richard H. Austing, University of Maryland
Frank Cable, Pennsylvania State University
Richard Ciero, Thomas Nelson Community College, Virginia
Benjamin Diamant, IBM Corporation, Woodbridge, Virginia
Gerald L. Engel, Virginia Institute for Marine Science, Virginia
Richard Gehrt, Employers Insurance of Wausau, Wisconsin
Malcolm Gotterer, Florida International University
Majorie Leeson, Delta College, Michigan
Ronald Lenhart, Yavapai College, Arizona
Doris K. Lidtke, Towson State College, Maryland
Joyce Currie Little, Community College of Baltimore, Maryland
John Maniotes, Purdue University, Calumet Campus, Indiana
Robert R. Pearson, North Carolina Educational Computer Services
Harice Seeds, Los Angeles City College, California
George Sotas, U.S. Government Accounting Office
Robert Thorn, Computer Related Services, Norfolk, Virginia
John W. Westley, Illinois Central College, East Peoria, Illinois
James D. Wintress, Aetna Life and Casualty, Hartford, Connecticut

Workshop Participants, February 1977, Atlanta, Georgia

Richard H. Austing, Universiuty of Maryland, College Park, Maryland
Donald Beil, Rochester Institute of Technology, Rochester, New York
Priscilla Caira, Whittier Regional Voc-Tech High School, Haverhill, Massachusetts
Tom Cashman, Long Beach Community College, Long Beach, California
Richard Ciero, Thomas Nelson Community College, Hampton, Virginia
Sylvia Charp, Philadelphia School District, Philadelphia, Pennsylvania
Gerald L. Engel, Virginia Institute for Marine Sciences
Gary Gleason, Pensacola Junior College, Pensacola, Florida
Dan Kamerman, Robert J. Brady Co., Bowie, Maryland
Iva Helen Lee, McLennan Community College, Waco, Texas
Majorie Leeson, Delta College, University Center, Michigan
John Lloyd, Montgomery College, Rockville, Maryland
Joyce Currie Little, Community College of Baltimore, Maryland
John Maniotes, Purdue University—Calumet Campus, Hammond, Indiana
Robert Marcus, Ethnotech, Inc., Lincoln, Nebraska
Michael Meehan, Winthrop Publishers, Inc., Cambridge, Massachusetts
Harice Seeds, Los Angeles City College, Los Angeles, California
Gary D. Shelly, Anaheim Publishing Co., Fullerton, California
Richard Slocum, University of Maine at Augusta, Augusta, Maine
Erwin Vernon, Sinclair Community College, Dayton, Ohio
Gerald Weinberg, Ethnotech, Inc., Lincoln, Nebraska

Workshop Participants, August 1977, Gloucester Point, Virginia

Richard H. Austing, University of Maryland, College Park, Maryland
Richard Ciero, Thomas Nelson Community College, Hampton, Virginia
John Dineen, Middlesex County College, Edison, New Jersey
Gerald L. Engel, Virginia Institute for Marine Sciences, Virginia
Donna Hutcheson, East Texas State University, Commerce, Texas
Iva Helen Lee, McLennan Community College, Waco, Texas
Marjorie Leeson, Delta College, University Center, Michigan
Joyce Currie Little, Community College of Baltimore, Maryland
John Lloyd, Montgomery College, Rockville, Maryland
Claudia E. Plog (Bette), El Centro College of the Dallas County Community College District, Dallas, Texas
Joseph Ramach, State of Maryland, Baltimore, Maryland
Harice Seeds, Los Angeles City College, Los Angeles, California
John P. Stonebeck, Northhampton County College, Bethlehem, Pennsylvania
John Sweeney, National Technical Institute for the Deaf, Rochester Institute of Technology, Rochester, New York
Erwin Vernon, Sinclair Community College, Dayton, Ohio
John W. Westley, Illinois Central College, East Peoria, Illinois
Jacqueline A. Wood, University of Alabama, Birmingham, Alabama
Raymond W. Woodcock, Boulder Valley Vocational-Technical Center, Boulder, Colorado

Additional Contributors or Reviewers

Walter Anderson, U.S. Government Accounting Office, Washington, D.C.
Julius A. Archibald, Jr., SUNY at Plattsburgh, New York
Barry L. Bateman, Southern Illinois University at Carbondale
Robert Bise, Orange Coast College, California
Hoyle Blalock, Jr., Central Piedmont Community College
Joseph J. Cebula, Community College of Philadelphia, Pennsylvania
Jane Chapman, Paducah Community College, Kentucky
Frank Connolly, Montgomery Community College, Maryland
William W. Cotterman, Georgia State University, Atlanta, Georgia
J. Daniel Couger, University of Colorado, Colorado
Joan Culverhouse, McLennan Community College, Texas
John Dalphin, Indiana University, Purdue University, Fort Wayne, Indiana
Richard W. Dillman, Western Maryland College, Westminster, Maryland
Karen Eck, McDonnell-Douglas Automation Company, California
Robert Fox, College of duPage, Illinois
Michael Faiman, University of Illinois, Urbana, Illinois
Dan Fullerton, Albuquerque Technical-Vocational Institute, Albuquerque, New Mexico
David Gilmore, U.S. Office of Personnel Management, Washington, D.C.
Gary Gleason, Pensacola Junior College, Florida
Jim Gross, University of Wisconsin Center
William Gruener, Addison-Wesley Publishing Co., Reading, Massachusetts
John Hamblen, National Bureau of Standards
Carl Hammer, UNIVAC, a Division of Sperry Rand
Preston Hammer, Grand Valley State College, Michigan
Patricia Hendershot, U.S. Department of Agriculture, Washington, D.C.
Laureen M. Hendry, IBM Corporation, Atlanta, Georgia
Larry Jehn, University of Dayton, Ohio
Karl Karlstrom, Prentice-Hall, Inc., Englewood Cliffs, New Jersey
Ed Keith, Citrus College, California
Alton Kindred, Manatee Junior College, Florida
Ralph Lee, University of Missouri at Rolla
Charles Leidlich, Miami-Dade Community College, Florida
Theodore S. Lewis, Trident Technical College, Charleston, South Carolina
Donald W. Loveland, Duke University, North Carolina
Bernard Luskin, Coast College District, California
Sister Patricia Marshall, Xavier University of Louisiana
William McCartin, Noxell Corporation, Baltimore, Maryland
Daniel D. McCracken, McCracken Associates
Larry Newcomer, York Campus of Pennsylvania State University
Tom Oatney, Clark Technical College, Springfield, Ohio
Charles G. Peterson, Northwest State, Maryvale, Missouri
Montgomery Phister, Jr., Systems Consultant, Santa Monica, California
Lawrence D. Pickens, Del Mar College, Texas
Roger M. Polay, Washtenaw Community College, Ann Arbor, Michigan
Doug Ruby, McDonnell-Douglas Automation Company, California
Martin Sandman, National Cash Register, Inc.
Gary Shelly, Anaheim Publishing Company, California
Bobby Smith, City of Portsmouth, Virginia
B. D. Sorell, Kilgore College, Texas
Leslie S. Spencer, Indiana University of Pennsylvania
Nancy Stern, Hofstra University, Hempstead, New York
Walter S. Szalajka, Lewis University, Lockport, Illinois
Ralph A. Szweda, Monroe Community College, Rochester, New York
James Tuedio, Pasadena City College, Pasadena, California
Gerald M. Weinberg, Ethnotech, Inc., Lincoln Nebraska
Eric Weiss, Sun Company, Radnor, Pennsylvania
Frank M. White, Catonsville Community College, Maryland
Eric Whiteside, Miami-Dade Community College, Florida

Appendix F.

ACM Committee on Curriculum for Community and Junior College Education, 1981

Chair: Joyce Currie Little, Community College of Baltimore, Maryland[*]
Members: John (Jack) Dineen, Middlesex County College, Edison, New Jersey
Dennis Fletcher, Informatics, Inc., Canoga Park, California
Iva Helen Lee, McLennon Community College, Waco, Texas
Marjorie Leeson, Delta College, University Center, Michigan
John F. Schrage, So. Ill. Univ. at Edwardsville, Illinois
Harice Seeds, Los Angeles City College, California
John Sweeney, National Technical Institute for the Deaf, Rochester, New York
Erwin Vernon, Sinclair Community College, Dayton, Ohio
Ray Woodcock, Boulder Valley Voc-Tech Center, Boulder, Colorado

---

[*] Joyce Currie Little's current address is Towson State University, Dept. of Mathematics and Computer Science, Stephens Hall, Room 111, Baltimore, MD 21204.

GA
786.25
A97
1983
v.8

THE LIBRARY
UNIVERSITY OF CALIFORNIA
Santa Barbara

THIS BOOK IS DUE ON THE LAST DATE
STAMPED BELOW.

Series 9482

UC SOUTHERN REGIONAL LIBRARY FACILITY

D 000 735 696 7